Final
Environmental Impact Statement

Volume 1
Environmental Impact Statement

Sections 1 through 8

BOMARC MISSILE SITE
McGuire Air Force Base
New Jersey

HEADQUARTERS MILITARY AIRLIFT COMMAND
(HQ MAC/LEVC)
Scott Air Force Base, Illinois 62225
(618) 256-5763

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This document consists of the final EIS report for the BOMARC Missile Site, McGuire AFB, New Jersey. The BOMARC Missile Site became contaminated in 1960 as the result of a fire which partially consumed a nuclear warhead-equipped with BOMARC missile. The EIS evaluates the potential environmental impacts of the various alternatives proposed to affirmatively address the radioactive contamination at the BOMARC Missile Site. Of the alternatives evaluated, the Air Force's preferred alternative is the excavation and off-site disposal of contaminated soils, sediments, and structural materials.

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22a. NAME OF RESPONSIBLE INDIVIDUAL
Major John M. Clegg, Jr. P.E.

22b. TELEPHONE *(Include Area Code)*
(512)536-9001 (ext. 322)

22c. OFFICE SYMBOL
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EXECUTIVE SUMMARY

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This Environmental Impact Statement (EIS) is prepared in accordance with United States Air Force Regulation 19-2, the National Environmental Policy Act (NEPA) of 1969, and regulations promulgated by the President's Council on Environmental Quality (40 Code of Federal Regulations (CFR), Parts 1500 through 1508). This Final EIS evaluates the potential environmental impacts of the various alternatives proposed to affirmatively address the radioactive contamination at the Boeing Michigan Aeronautical Research Center (BOMARC) Missile Site. Of the alternatives evaluated, the Air Force's preferred alternative is the excavation and off-site disposal of contaminated soils, sediments, and structural materials. The Nevada Test Site is the preferred off-site disposal location.

BOMARC Missile Site History

The BOMARC Missile Site is an inactive Air Force installation located in Plumsted Township, New Jersey, and is maintained by McGuire Air Force Base (AFB). From 1958 until 1972, the BOMARC Missile Site was an active defensive nuclear missile site, housing missiles equipped with nuclear warheads. On June 7, 1960, a fire occurred in one of the on-site shelters housing a missile. The shelter, missile, and warhead were partially consumed by fire. The missile launcher, which was burned and partially melted, is believed to have been removed from the missile shelter shortly after the accident. However, no records are known to exist which indicate the manner or location of its disposal. Air Force procedures in effect at the time of the accident would have included removal of contaminated debris from the shelter for disposal as waste. Existing records indicate disposal of additional radioactive waste from the site at the Idaho National Engineering Laboratory. Records also indicate containment measures were applied to the missile shelter and the asphalt apron but are silent as to the launcher. Weapons-grade plutonium (WGP) from the nuclear warhead was dispersed to soils and structures in the immediate vicinity of the missile shelter. Portions of the site remain contaminated today. The primary contaminants of concern, Plutonium-239 (^{239}Pu) and Americium-241 (^{241}Am), have been detected in site soils, sediments, structural materials, and beneath a concrete/asphalt apron.

The Air Force has monitored, maintained control of, and limited access to the site for the 30 years since the fire. In January, 1989, the Air Force initiated a Remedial Investigation/Feasibility Study (RI/FS) of the site. The RI/FS and EIS were initiated because of the potential to utilize new technologies for radioactive waste cleanup. The EIS evaluated the different alternatives. The Air Force solicited public involvement in the process of considering which alternative to implement at the BOMARC Missile Site.

Extent and Magnitude of Contamination

The objectives of the RI/FS were to determine the extent and magnitude of radioactive contamination and to evaluate appropriate alternatives. The radiological contamination at the BOMARC Missile Site consists of WGP. The primary isotope in WGP is ^{239}Pu, but small quantities of ^{238}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am (from beta decay of ^{241}Pu) are also present. No concentrations of radionuclides attributable to the missile accident were detected in groundwater, surface water, or air at the site. Contaminants attributable to the missile accident were detected in shallow soils, sediments, and structural materials including the concrete/asphalt apron, the missile shelter, and the underground utility bunkers adjacent to the missile shelter. Distribution of contaminants was found to be consistent with that observed in previous studies, indicating little active transport of contaminants. The current distribution of contaminants is primarily the result of dispersion caused by the 1960 accident and subsequent fire-fighting efforts rather than active environmental transport of contaminants.

Alternatives

This Final EIS was prepared to evaluate and compare the environmental impacts of alternatives for the BOMARC Missile Site. One of the alternatives, the Unrestricted Access Alternative, is not considered acceptable by the Air Force but was evaluated in this EIS to provide a worst-case scenario and to maintain consistency with the RI/FS. This alternative was considered because of the long half-life of plutonium. The Air Force's preferred alternative, Off-site Disposal, was identified after review of the EIS and evaluation of comments received during the public hearing and the public comment period.

The five alternatives that were evaluated in detail include:

- **Unrestricted Access**: This alternative was evaluated because it represented a hypothetical worst case where control of the site is assumed to be lost in the distant future. Radioactive contamination would potentially be of concern in the future due to the long half-life of ^{239}Pu (24,400 years). If Unrestricted Access were to occur, contaminated materials would be left as they are. Current management practices including *access controls*, monitoring, and maintenance would not occur. No remedial cleanup measures would be implemented.

- **NEPA No Action**: If this alternative were implemented, current management practices would continue. These practices include access restrictions, maintenance of existing containment structures, and monitoring of site conditions.

- **Limited Action**: If this alternative were implemented, current management practices would continue. These practices include access restrictions, maintenance of existing containment structures, and monitoring of site conditions. A limited amount of the materials at the site, specifically the missing missile launcher, would be searched for and removed, if located. There is no information indicating that the launcher and associated equipment were contaminated or were disposed of on-site. Reasonable effort will be used to find the launcher, however, the launcher may never be located.

- **Off-site Disposal**: This is the alternative identified as the Preferred Alternative. Implementation of this alternative would involve removal of contaminated soils and structural materials including the missile launcher and miscellaneous shelter debris. There is no information indicating that the launcher and associated equipment were contaminated or were disposed of on-site. Reasonable effort will be used to find the launcher, however, the launcher may never be located. The contaminated materials would be removed from the site and disposed in an appropriate, off-site radioactive waste disposal facility.

- **On-site Treatment**: If this alternative were implemented, radioactive contaminants from soils and structures including the missile launcher and miscellaneous shelter debris, if located, would be removed through on-site physical treatment processes and disposed of in an appropriate, off-site radioactive waste disposal facility.

For this EIS, two radioactive waste disposal facilities have been evaluated. These facilities include U.S. Ecology's Hanford Site in Washington and the Department of Energy's (DOE's) Nevada Test Site. These two facilities are representative of the types of radioactive waste facilities available (i.e., Hanford is commercially operated, whereas the Nevada Test Site is a government facility). Because disposal costs at commercial facilities are significantly greater than at government facilities, the Air Force's preferred disposal site is the Nevada Test Site. The excavated material would be transported by truck, the safest, most cost effective mode of transport. Costs of the five alternatives evaluated in the EIS are summarized in Table ES-1.

Impacts to both physical and human resources were evaluated. The physical environment includes geology and soils, hydrology, surface and groundwater, air quality, and flora and fauna. Human resources include transportation, land use, and public health.

Different methods of assessing impacts were employed depending on the type of alternative. Two alternatives, Limited Action and On-site Treatment, would include invasive activities and would also involve short-term disruption of the environment. Therefore, impacts for these alternatives are addressed both in the short-term, while the invasive activities are ongoing, and in the long-term, after remedial activities are complete. One alternative, NEPA No Action, does not involve invasive activities. Therefore, short- and long-term impacts were not distinguished. One alternative, Unrestricted Access, assumes that control of the site is lost, so impacts to the physical environment were assessed assuming that natural processes would occur. It was also assumed that at some point in time uncontrolled site development could occur. To assess impacts to public health, a two-part scenario (construction/resident) which is used by the Nuclear Regulatory Commission, was adapted and used for the Unrestricted Access Alternative.

Impact Analysis

Impacts of the five alternatives for each environmental category evaluated in the EIS are summarized below and in Table ES-1. Impacts to each of the resource areas were assessed using various methodologies. Details of the methodologies are provided as appendices to the EIS. In general, the level of impact was determined based on the relationship between the impact and a standard such as a regulatory requirement or a health-based cleanup level established in the RI/FS. Impacts were ranked as negligible, low, moderate, or high.

Unrestricted Access Alternative. If this scenario were to occur, there would be no institutional controls exercised over the site. Potential uses of the site are, therefore, speculative. To ensure consistency between impact assessments for each resource area, two scenarios were established. For the first scenario, it was assumed that natural processes at the site would proceed without human intervention. For the second scenario, it was assumed that the site would be subject to invasive human activities such as excavation.

Table ES-1
Comparison of Alternatives

	Unrestricted Access		NEPA No Action	Limited Action		Off-site Disposal		On-site Treatment	
	Natural Conditions	Uncontrolled Site Development		Short-Term	Long-Term	Short-Term	Long-Term	Short-Term	Long-Term
Geology & Soils	L	H	N	N	N	N	N	N	N
Hydrology									
Surface Water	L	H	N	N	N	N	N	N	N
Groundwater	L	H	N	N	N	N	N	N	N
Air Quality	N	H	N	L	N	M	N	M	N
Biology									
Flora	L	H	N	N	N	L	M	L	M
Fauna	L	H	N	N	N	L	L	L	L
Organism Contamination	L	H	N	L	N	L	N	L	N
Transportation	N	H	N	N	N	N	N	N	N

	Current	Future	Current	Future	Current	Future	Current	Future	Current	Future
Land Use	N	H	N	M	N	M	N	N	N	N

	Intruder						
	Construction	Residence	Population	Population	Population	Population	Population
Public Health	H	H	N	N	N	N	N

	Unrestricted Access	NEPA No Action	Limited Action	Off-site Disposal	On-site Treatment
Costs[a]	No Cost	$789,000	Nevada Test Site $957,000 Hanford Washington Site $1,183,000	Nevada Test Site $6,800,000 Hanford Washington Site $23,105,000	Nevada Test Site $8,464,000 Hanford Washington Site $13,533,000

N = Negligible; L = Low; M = Moderate; H = High.

[a] Thirty-year present worth cost at 0.10 interest, including capital, operations and maintenance. One-time costs are assumed to be incurred in a period of one year at present worth. Details of the cost estimates are found in the RI/FS, Section 5.3.

Under the first scenario, this alternative would have negligible impacts on air quality, land use, and transportation. There could be low impacts to geology and soils, as the soil erosion rate could slightly increase, and to flora, as endangered species' habitats could be altered. The surface water and groundwater flow regimes could be altered, the faunal populations and their habitats could be altered, and the potential for bioassimilation would increase.

Under the second scenario, if the site is subject to invasive human activities, there could be high impacts to soils since the soil erosion rate could substantially increase; surface and groundwater quality, quantity, or flow regime could be adversely altered; ambient levels of air pollutants could increase. Floral and faunal habitats and populations could be substantially altered, and the potential for bioassimilation could be increased. The traffic volume and transportation infrastructure could be altered. There could be moderate impacts to land use if conflicts arise with future uses of land in adjacent jurisdictions. Potential health impacts to the general public and to a potential intruder on the site were also assessed; health impacts would be high for an intruder and negligible to the public.

There would be no cost associated with this alternative.

NEPA No Action Alternative. Implementation of this alternative would entail continued institutional control of the site. Thus, the existing structures and surfaces would be maintained. These features attenuate some of the potential for off-site migration of contaminated soils. Implementation of this alternative would have negligible impacts on all of the resource areas evaluated in the EIS except for land use. Impacts to land use were estimated to be moderate, since the possibility of any alternate future use of the site would be foregone.

The cost of implementing this alternative would be approximately $789,000, as estimated in the RI/FS. It should be noted that this cost is based on a thirty year projection of present worth which is an accepted standard for comparison costing. Actual costs for the NEPA No Action Alternative would be higher than shown because costs would be incurred in perpetuity as activities involved in this alternative would be required into the distant future.

Limited Action Alternative. This alternative is similar to the NEPA No Action Alternative but also involves an attempt to locate the missing missile launcher. Therefore, impacts were evaluated for the short term, while remediation activities are ongoing, and for the long term, after remedial activities are complete.

Short-term impacts would be negligible for geology and soils, hydrology, flora, fauna, transportation, and land use. There would be low impacts to air quality as a result of fugitive dust and vehicular emissions and low impacts to fauna because of the potential for increasing bioassimilation of contaminants.

In the long-term, there would be negligible impacts to geology and soils, hydrology, air quality, biology, and transportation. Impacts to land use would be moderate because the possibility of any alternative future use of the site would be foregone. Health impacts to the public were examined and were determined to be negligible.

The cost of implementing this alternative was estimated in the RI/FS to be approximately $957,000 (for disposal of radioactive materials at the Nevada Test Site) or $1,183,000 (for disposal at Hanford, WA). The cost estimate assumes the missile launcher is located. It should be noted, this cost is based on a thirty year projection of present worth which is an accepted standard for comparison costing. Actual costs for the Limited Action Alternative would be higher than shown because costs would be incurred in perpetuity as activities involved in this alternative would be required into the distant future.

Off-site Disposal Alternative. The Preferred Alternative would involve intrusive excavation activities. Therefore, impacts were evaluated for both short and long term. Under the Off-site Disposal Alternative, short-term impacts would be negligible for geology and soils, hydrology, transportation, and land use. There would be low to moderate impacts to flora and fauna. Habitats would be lost, fauna would be displaced, and the potential for bioassimilation would increase. Moderate short-term impacts to air quality would occur since there would be an increase in ambient levels of fugitive dust and emissions.

In the long-term, there would be negligible impacts to geology and soils, hydrology, air quality, transportation, and land use. There would be low impacts to fauna from localized faunal displacement. Impacts to flora would be moderate as threatened plants may be displaced. Health impacts were determined to be negligible.

The cost of implementing this alternative was estimated in the RI/FS to be approximately $6,800,000 (for disposal at the Nevada Test Site) or $23,105,000 (for disposal at Hanford, WA).

On-site Treatment Alternative. This alternative also involves remedial activities, so both short- and long-term impacts were assessed. Under the On-site Treatment Alternative, short-term impacts would be negligible for geology and soils, hydrology, transportation, and land use. There would be low to moderate impacts to flora and fauna. Habitats would be lost, fauna would be displaced, and the potential for bioassimilation could increase. Moderate short-term impacts to air quality would occur since there would be an increase in ambient levels of fugitive dust and emissions.

In the long-term, there would be negligible impacts to geology and soils, hydrology, air quality, transportation, and land use. There would be low impacts to fauna from localized faunal displacement. Impacts to flora would be moderate as threatened plants may be displaced. Health impacts were determined to be negligible.

The cost of implementing this alternative was estimated in the RI/FS to be approximately $8,464,000 (for disposal at the Nevada Test Site) or $13,533,000 (for disposal at Hanford, WA).

Scoping Issues & Public Comments

Public concerns were identified during the scoping process. The impact analysis addressed the issues identified during the scoping process. The resolution to those issues is summarized below.

The potential for airborne transport and deposition of radiation over adjoining townships was a scoping issue. In addition to the Preferred Alternative, two alternatives (Limited Action and Off-site Disposal) have the potential to increase airborne transport of contaminants. General mitigations for these alternatives have been incorporated into the descriptions of alternatives. They include engineering controls and design features which would decrease the potential for such transport and dispersion. Prior to implementation of the Preferred Alternative or any alternative requiring extensive excavation, a remedial design would be developed. The remedial design would include detailed plans related to mitigations of potentially adverse impacts.

The potential for release of plutonium through surface and groundwater media was another scoping issue. Plutonium, however, is a low-solubility metal which is highly sorptive and adheres to fine soil particles. Two of the alternatives (Off-site Disposal and On-site Treatment) would involve excavation and removal of most of the contaminants at the site which would further reduce the already low potential for release of plutonium through surface and groundwater media.

Another scoping issue was the potential for any removal action to disturb the site and release radiation. Three alternatives involve site disturbance: Limited Action, Off-site Disposal, and On-site Treatment. Two alternatives (Unrestricted Access and NEPA No Action) may, over the long term, increase the potential for soil erosion which would, therefore, increase the potential for releases off-site. The Off-site Disposal and On-site Treatment Alternatives incorporate mitigations which reduce the potential for soil erosion problems.

Another scoping issue was the potential problem associated with identifying a waste depository and the risk of transporting plutonium-contaminated soils and debris. Off-site Disposal and two other alternatives (Limited Action and On-site Treatment) could involve the off-site transport of radioactive waste. The RI/FS identified two potential waste repositories: U.S. Ecology's Hanford, WA site and the Nevada Test Site. The relative risks associated with transportation of radioactive wastes have been evaluated in a variety of other EISs. These documents assessed the potential environmental impacts associated with land transportation of radioactive wastes which are regulated by Federal and state agencies. In general, these previous EISs and studies have concluded that transportation of radioactive wastes in compliance with applicable regulations does not pose a threat of significant impacts to human health or the environment.

Another scoping issue was the difficulty in ensuring that the BOMARC Missile Site would not be disturbed as long as the health threat from radioactive contamination exists. The Unrestricted Access Alternative was developed to identify the potential impacts if control of the site was lost. The alternative was evaluated as a worst-case scenario and potentially significant high impacts were identified.

There were several scoping issues related to flora and fauna at the site. Issues included: the need for a complete faunal survey and an assessment of the potential for biological uptake of plutonium contamination; the need to sample potentially exposed wildlife; the potential for active transport of radioactive plutonium or americium by animals living on the site. An extensive literature search was conducted to compile detailed vegetation, habitat, and faunal inventories. Field surveys (vegetative and habitat) were conducted. A detailed technical literature search was conducted which indicated that plutonium released to the environment is not concentrated in terrestrial plants and the magnitude of plant to animal concentration is low.

A EIS was filed with the EPA on September 6, 1991. A 45 day public comment period was provided. A public hearing was announced, publicized and held in the New Hanover Township, Municipal Building in Cookstown, New Jersey on October 3, 1991.

At the Public Hearing and in the written comments, most commentors indicated that the Air Force should select one of the two active remedial alternatives (Off-site Disposal or On-site Treatment). There were several commentors who expressed a preference for the NEPA No Action and Limited Action Alternatives. Two issues noted by many commentors relate to the amount of residual plutonium remaining on-site and the selection of a cleanup level for the Off-site Disposal and On-site Treatment Alternatives.

Verification of the amount of plutonium remaining on-site requires a validation of the amount that was removed after the accident. The total amount of plutonium in the BOMARC missile warhead is classified information. To validate that amount of plutonium estimated to remain on-site, an unclassified report was prepared by DOE and the Air Force and is included in this EIS. The report indicates that the amount of plutonium remaining on-site does not exceed 300 grams.

Implementation of the Off-site Disposal Alternative requires the calculation of an appropriate cleanup level. To clarify and refine and improve the cleanup level established in the EIS, the approach used in the radiological assessment was modified. The risk based cleanup level was based directly on the output from a computer program designed to calculate soil cleanup criteria. An effective dose equivalent of 4 millirem per year was used by the model as the dose limit for derivation of the cleanup level. This dose represents an acceptable lifetime cancer risk of less than 10^{-4}.

All of the alternatives except Unrestricted Access achieve risk reduction by eliminating the exposure scenario that causes risk (intruder scenario). Neither the NEPA No Action nor the Limited Action Alternatives achieves quantitative health-based or regulatory-based cleanup criteria that were established in the RI/FS since neither of these alternatives achieves reduction of mobility, toxicity, or volume.

Both the On-site Treatment and the Off-site Disposal Alternatives achieve health-based and regulatory-based cleanup criteria that were established in the RI/FS. The On-site Treatment Alternative achieves these goals through waste volume reduction. Soils and materials that could not be treated on-site would be physically removed from the site to a radioactive waste disposal facility. The Off-site Disposal Alternative achieves risk reduction by eliminating any potential for exposure to radiological contamination at the site. In this case, all contaminated soils and materials would be excavated and physically removed.

Of the alternatives presented in Section 2.0 of this EIS, the Air Force has identified the Off-site Disposal Alternative with disposal at a Department of energy low-level radioactive waste disposal site as the Preferred Alternative. There are however, a number of issues that may impact the Air Force's ability to make an independent decision on the BOMARC Missile Site.

Because of this, the possibility exists that the Air Force would be forced to select the NEPA No Action Alternative.

There are currently only three operating commercial low-level radioactive waste disposal facilities in the nation licensed to receive the radioisotopes present as contamination on the BOMARC Missile Site. They are the Chem-Nuclear facility in Barnwell, South Carolina, and the U.S. Ecology facilities in Beatty, Nevada, and Hanford, Washington. An additional facility licensed for disposal of bulk materials and operated by Envirocare, Inc. located in Utah, has applied for an amendment to its license for plutonium and may also be available.

The Air Force prefers to dispose of the BOMARC waste in a DOE low-level radioactive waste facility because disposal costs are a significant factor. Costs for disposal at a commercial site are significantly greater than disposal at a DOE facility. The cost of disposing of BOMARC Missile waste at the U.S. Ecology Hanford site is estimated to be $24 million where as disposal at the DOE's Nevada Test Site is estimated to be $7 million.

The Air Force has no firm response from the DOE as to whether or not DOE will accept the BOMARC waste. It is the Air Force's understanding that the DOE will not consider acceptance of the waste unless the Air Force has been refused disposal permission at all available commercial sites. The Air Force believes it is currently in good standing with the commercial waste sites and has applied for permission to dispose of the BOMARC waste at all four commercial facilities. No response has yet been received from any of the four commercial sites.

The issue that will most impact the Air Force's ability to make an independent decision is the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) governing interstate shipment and disposal of radioactive waste. The LLRWPAA places the burden for low-level radioactive waste disposal with the individual states, or with compacts of states, and establishes a schedule for phased implementation. This act has already increased the cost of disposal at the licensed commercial sites through its provisions allowing currently sited states to levy waste surcharges. Costs are projected to escalate even more as states and compacts set fees to support their sites' operations. A more immediate issue affecting any decision is the scheduled closure of the commercial sites on January 1, 1993. On that date, another provision of the LLRWPAA takes effect that closes existing commercial sites to generators outside the state or compact in which the site is located. As state and compact agreements now stand, waste generators in New Jersey will have no access to existing sites even if they remain open to member states within the sites' compacts.

The Air Force cannot make a decision on the BOMARC Missile Site that involves disposal until sites willing to accept the waste have been identified and costs analyzed for effectiveness. The NEPA No Action Alternative would be implemented by default if permission is not secured or if disposal options are not cost effective.

In the event NEPA No Action Alternative is implemented, radioactive contamination would remain in-place, and access controls and environmental monitoring would continue until such time that a viable, economically feasible off-site disposal facility becomes available.

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GLOSSARY

AAQS	Ambient Air Quality Standards
Action level	The existence of a contaminant concentration in the environment high enough to warrant action or trigger a response under SARA and the National Oil and Hazardous Substances Contingency Plan.
AFB	Air Force Base
ALARA	As Low As Reasonably Achievable
Alluvium	Sedimentary materials deposited in an environment of flowing surface waters.
Americium	Radioactive element resulting from the radioactive decay of plutonium.
AQCR	Air Quality Control Region
Aquifer	Zone beneath the earth's surface capable of producing water for a well.
Aquitard	A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer.
ARARs	Applicable or Relevant and Appropriate Requirements
Atmospheric dispersive potential	The potential for the atmosphere to disperse air pollutants. This is based on wind speed, atmospheric stability, and the depth of the layer through which effective mixing may take place.
Atmospheric stability	A measure of air turbulence defined in terms of atmospheric temperature profile.
Bioassay	Measurement of internally deposited radioactivity by analysis of blood, urine, or feces.
BEIR	Biological Effects of Ionizing Radiation
BOMARC	Boeing Michigan Aeronautical Research Center
Buoyant	With the ability to ascend in the atmosphere, by thermal or mechanical means.
CAA	Clean Air Act

CEQ	Council of Environmental Quality
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
cfs	Cubic feet per second
csm	Cubic feet per second per square mile
cpm	Counts per minute
Criteria pollutant	Those pollutants regulated by the National Ambient Air Quality Standards.
CWA	Clean Water Act
cwt	Hundredth Weight
Curie	A unit of radioactivity; the amount of any nuclide that undergoes exactly 3.7×10^{10} radioactive disintegration per second.
Decontamination	The removal of radioactive material from the surface or from within another material.
DoD	Department of Defense
DOE	Department of Energy
Dose	A general term denoting the quantity of radiation or energy adsorbed. For special purposes, it must be appropriately qualified. If unqualified, it refers to adsorbed dose.
Dose conversion factors	For external radiation dose, the ratio of the radiation dose received to the concentration of a radioactive substance in the environment (i.e. in the air or on the ground). For internal radiation dose, the ratio of the radiation dose received to the amount of radioactivity consumed (i.e. by inhalation or ingestion).
Dose equivalent	A unit of radiological dose; it is a measure of the risk associated with exposure to a given level of radiation, measured in rem.
Dosimetry	The process of measuring or calculating doses from radiation or internally deposited radioactivity.
dpm	Disintegrations per minute; The rate of emission by radioactive material as determined by the number of nuclei that decay each minute.

EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
Evapotranspiration	The loss of water from the soil both by evaporation and by transpiration from plants.
External radiation dose	Radiation dose resulting from exposure to radiation sources outside the body such as radioactive material in surface soils.
Fallout	Radioactivity resulting from a nuclear explosion and descending through the atmosphere.
FIDLER	Field Instrument for the Detection of Low Energy Radiation
Fugitive emissions	Emissions of a transitory nature, such as a fugitive dust which may be suspended in the atmosphere due to wind erosion or mechanical disturbance of soils.
g	gram
GENII	Computer Code developed to assess the radiological consequences of releases to the environment.
Half-life	The time required for half of a sample of a radioactive isotope to decay.
HEPA	High-Efficiency Particulate Air
Hydraulic gradient	Change in pressure or head in groundwater over a given distance of flow.
IM-99A	Liquid-Fueled BOMARC Interceptor Missile, Model A
IM-99B	Solid-Fueled BOMARC Interceptor Missile, Model B
Internal radiation dose	Dose resulting from radioactive material that is deposited in organs and tissues by means of ingestion or inhalation.
ion	An atom or a group of atoms that has gained or lost electrons resulting in a net electric charge.
Isotope	Different forms of the same chemical element, which are distinguished by having different numbers of neutrons, but the same number of protons.
Johnson RML 1-A	A radiation detection instrument used for personal screening.

JP-X	Grade of jet fuel used at Air Force installations.
Landfill Cells	Constructed sections of a landfill where waste is dumped, compacted, and covered with layers of dirt on a daily basis.
LOI	Level of Impact
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act
LLW	Low-level radioactive waste
LST	Local Standard Time
m per s	Meters per second
MATS	Military Air Transport Service
MDR	Methodology Development Report
mg per L	Milligrams per liter (equivalent to parts per million in water)
mg per kg	Milligrams per kilogram (equivalent to parts per million in solids)
Mitigation measures	Measures taken to lessen the severity of an impact, such as the impact associated with the action of remediation.
Mixing height or depth	The height or depth of the layer, nearest the earth's surface, through which vigorous atmospheric mixing will occur.
MM	Modified Mercalli Scale
mph	Miles per Hour
mrem	millirem
MSL	Mean Sea Level
MTV	Mobility, Toxicity, and Volume
NAEC	Naval Air and Engineering Center
NCP	National Contingency Plan
NEPA	National Environmental Policy Act of 1969
NIPDWR	National Interim Primary Drinking Water Regulations

NJANG	New Jersey Air National Guard
NJDEPE	New Jersey Department of Environmental Protection and Energy
NJDOT	New Jersey State Department of Transportation
NJPCMP	New Jersey Pinelands Comprehensive Management Plan
NRC	Nuclear Regulatory Commission
NTIS	National Technical Information Service
OEHL	Occupational and Environmental Health Laboratory (USAF)
PAC-4G	Alpha radiation detection instrument
PM_{10}	Particulate matter less than 10μm in diameter.
Plutonium	Radioactive element used in nuclear warheads.
picocurie	One trillionth of a curie (10^{-12} curies), abbreviated pCi
PNRA	Pinelands National Reserve Area
Pollutant loading	A term referring to the amount and types of atmospheric pollutants.
ppb	Parts per billion
ppm	Parts per million
PSD	Prevention of Significant Deterioration
QAPP	Quality Assurance Project Plan
QC	Quality Control
Radioactive decay product	Radioactive material produced by the decay of another radioactive substance; also known as "daughter radionuclides" or "radioactive progeny."
Radionuclide	Radioactive element characterized according to its atomic mass and atomic number which can be manmade or naturally occurring.
RCRA	Resource Conservation and Recovery Act
Remedial measures	Those actions taken at a site, which are intended to provide a remedy or solution to a problem.

Remediation	The act or process of ameliorating a given problem.
Removable contamination	Contamination that is easily removed by applying moderate pressure to wipe the area with dry filter or soft absorbent paper.
RESRAD	Computer code developed specifically for the purpose of determining cleanup criteria for radioactively contaminated soils.
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROI	Region of Influence
SAC	Strategic Air Command
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act of 1986
Saturated zone	A subsurface area in which all pores and cracks are filled with water under pressure which is equal to or greater than that of the atmosphere.
Screening limit	An established limit of measurable radiation that should not be exceeded to ensure that individuals do not receive a radiation dose in excess of acceptable levels. This is not a regulatory requirement, but is used for guidance.
SIP	State Implementation Plan - a plan developed by each state to delineate plans directed toward achievement and compliance with the National Ambient Air Quality Standards.
Somatic	Cells of the body, as distinct from the germ line.
Stratification	Separating into layers.
TDS	Total Dissolved Solids
TETC	The Earth Technology Corporation
Transuranic material	Material containing elements with atomic number greater than 92 (uranium).
TRU-Clean^{R}	A physical separation process used to treat radioactively-contaminated soil.
Unconfined aquifer	An aquifer in which there are no confining beds between the zone of saturation and the surface.

Unconsolidated sediments	Sediments that are uncemented and thus contain interconnected void spaces (primary porosity) that allow for the storage and transmission of groundwater.
Unsaturated zone	The area above the water table where soil pores are not fully saturated, although some water may be present.
USAF	United States Air Force
USAFOEHL	United States Air Force Occupational and Environmental Health Laboratory
USFWS	US Fish and Wildlife Service
USLE	Universal Soil Loss Equation
VOC	Volatile Organic Compound
VOS	Volatile Organic Substance
vpd	vehicles per day
WGP	Weapons Grade Plutonium
WIPP	Waste Isolation Pilot Plan
°F	Degrees fahrenheit
μCi per m^2	Microcuries per square meter
μg per kg	Micrograms per kilogram (equivalent to parts per billion in solids).
μg per L	Micrograms per liter (equivalent to parts per billion in water).

UNITS/CONVERSIONS CHART

Knots	1 knot is equal to 1.151 statute miles per hour.
mg per L	Milligrams per liter (equivalent to parts per million in water).
mg per kg	Milligrams per kilogram (equivalent to parts per million in solids).
Micrometer	1 micrometer is equal to 1/1,000,000 meters.
Nautical Miles	1 nautical mile is equal to 0.8684 statute miles.
μg per kg	Micrograms per kilogram (equivalent to parts per billion in solids).
μg per L	Micrograms per liter (equivalent to parts per billion in water).

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SECTION 1.0

PURPOSE AND NEED FOR THE PROPOSED ACTION

1.0 PURPOSE AND NEED FOR THE PROPOSED ACTION

The Boeing Michigan Aeronautical Research Center (BOMARC) Missile Site is an inactive United States Air Force installation maintained by McGuire Air Force Base (AFB). There are radioactive contaminants present at the BOMARC Missile Site. The Air Force has maintained, monitored, and restricted access to the site since the site was contaminated in 1960. In early 1989, the Air Force initiated a major effort, in the form of a remedial investigation/feasibility study (RI/FS) in order to definitively document the extent of radioactive contaminants at the BOMARC Missile Site. With this definitive documentation, the Air Force could then proceed to propose actions which would affirmatively address and resolve the radioactive contamination at the BOMARC Missile Site. The primary goal of any proposed action would be the protection of human health and the environment. The RI/FS identified a number of alternative courses of action the Air Force could take to address the contaminants. The Environmental Impact Statement (EIS) evaluated the impacts associated with each potential course of action identified in the RI/FS. Based on the information contained in the EIS, the Air Force identified a preferred alternative which addresses the radioactive contamination at the BOMARC Missile Site.

1.1 Background and History

This section describes the background and history of the accident and fire that occurred at the BOMARC Missile Site. The extent of contamination and the volumes and types of contaminated materials present at the site are also described.

1.1.1 Description and History of McGuire AFB and BOMARC Missile Site

McGuire AFB occupies 3,536 acres in south-central New Jersey, 18 miles southeast of Trenton, New Jersey (Figure 1-1). McGuire AFB borders the U.S. Army Fort Dix installation on the eastern, southern, and western boundaries.

McGuire AFB leases the BOMARC Missile Site land from Fort Dix. The site is detached from and lies approximately 11 miles east of McGuire AFB. The BOMARC Missile Site occupies approximately 218 acres to the east of Ocean County Route 539 in Plumsted Township, Ocean County, New Jersey. The BOMARC Missile Site is east of the Fort Dix Military Reservation (Figure 1-2).

In 1937, the facility that was to become McGuire AFB was a dirt-strip runway called Rudd Field. It was developed as an adjunct to the U.S. Army Training Center at Fort Dix, and was operated by the U.S. Army Air Corps. The airfield remained under Army control until 1948. In 1948, the Fort Dix Airfield, and all existing facilities were transferred to the Air Force, and was officially designated Thomas B. McGuire, Jr. AFB. The present host organization at McGuire AFB is the 438th Airlift Wing, which is responsible for operating McGuire AFB, and for providing adequate support to a large number of tenant units.

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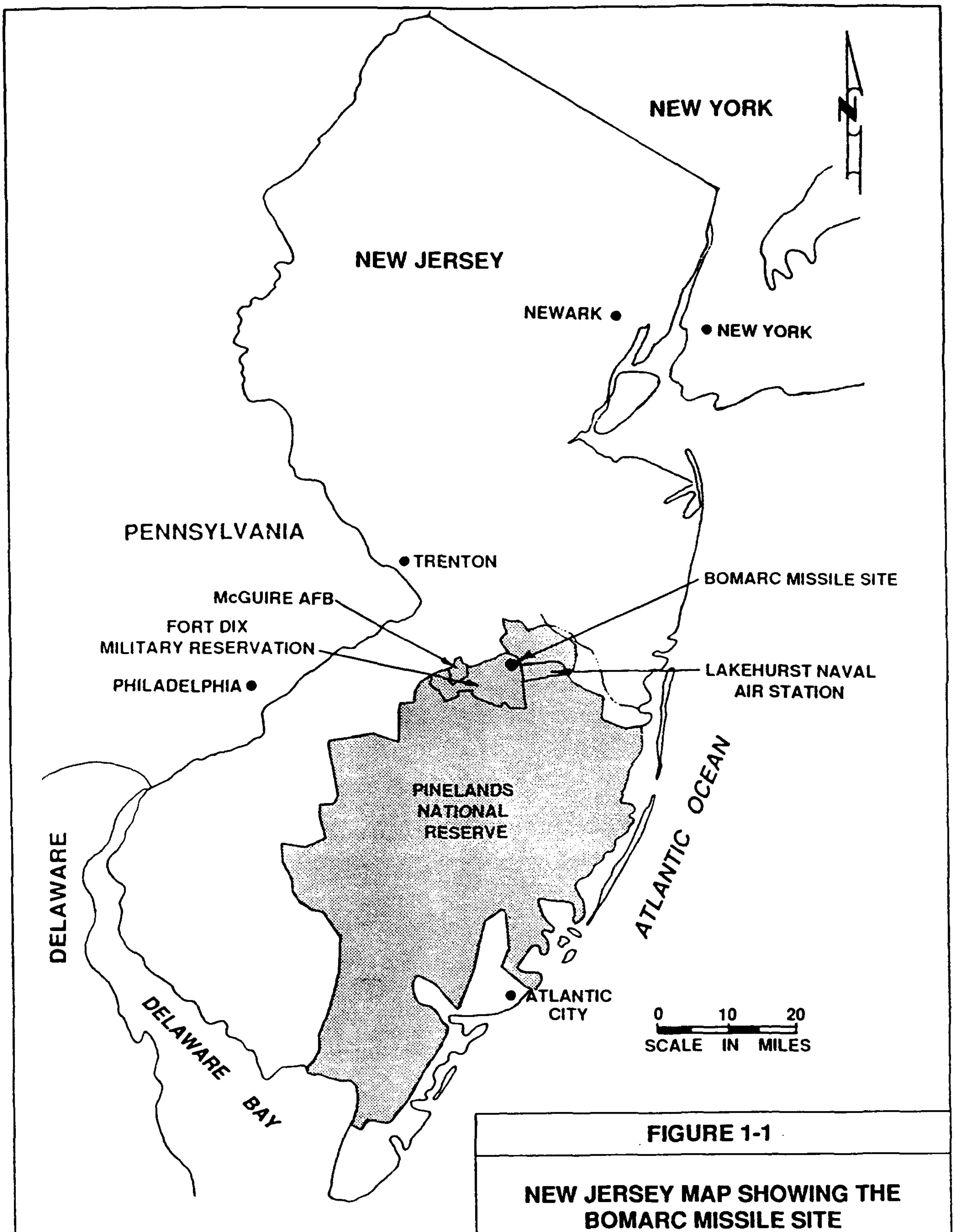

FIGURE 1-1

NEW JERSEY MAP SHOWING THE BOMARC MISSILE SITE

Source: Battelle, 1988.

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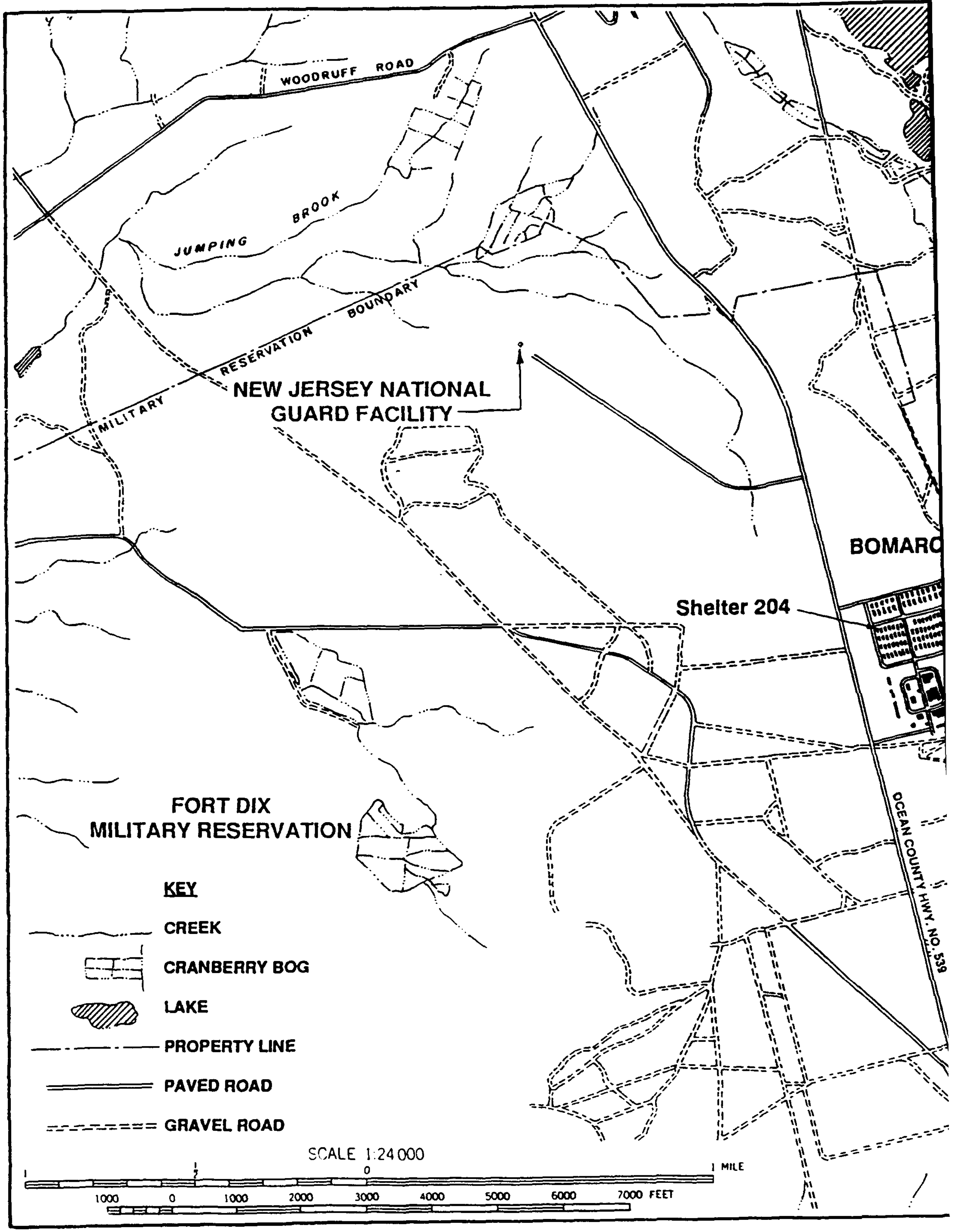
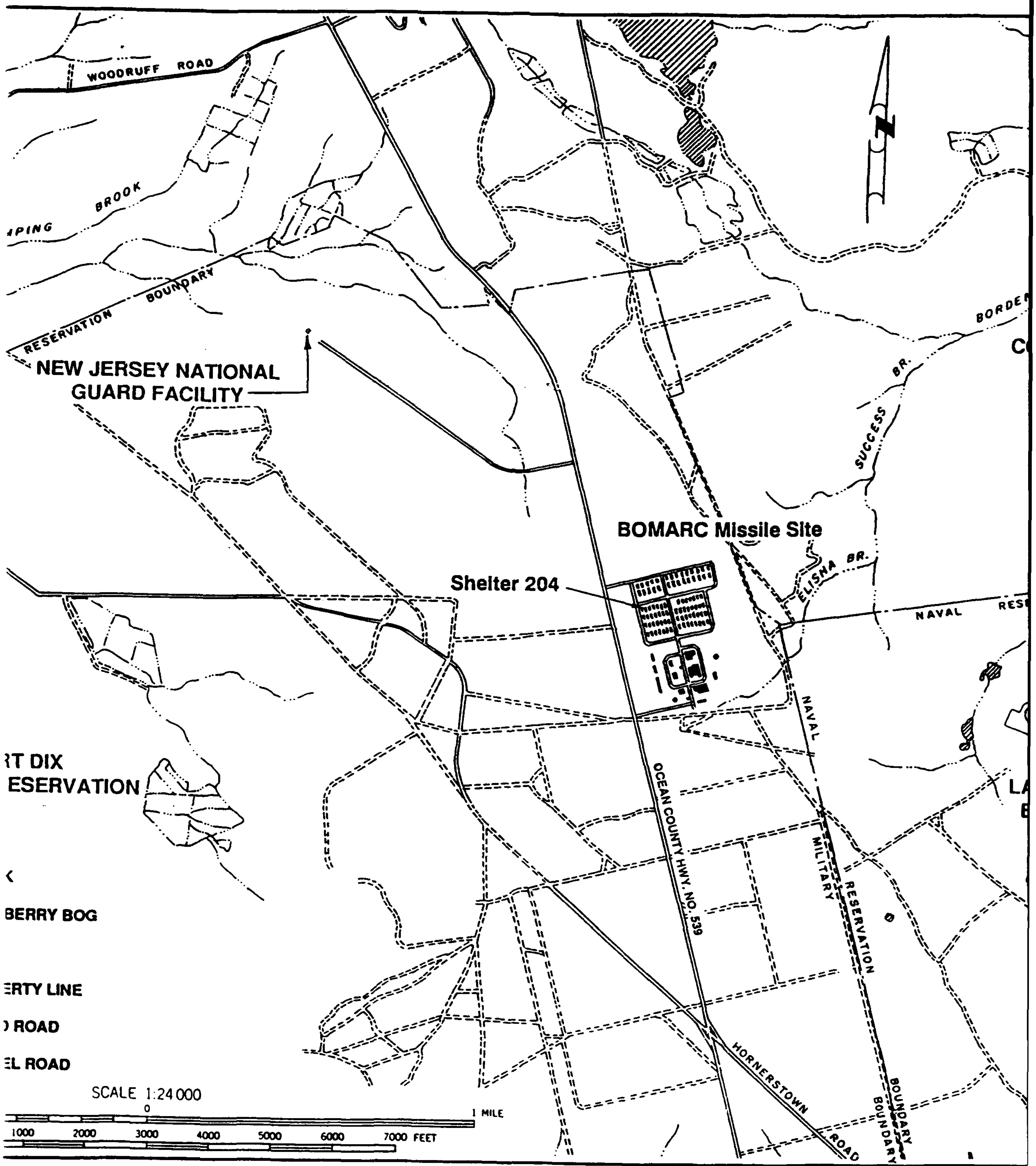

WOODRUFF ROAD
JUMPING BROOK
MILITARY RESERVATION BOUNDARY
NEW JERSEY NATIONAL GUARD FACILITY
BOMARC
Shelter 204
OCEAN COUNTY HWY. NO. 539
FORT DIX MILITARY RESERVATION
KEY
CREEK
CRANBERRY BOG
LAKE
PROPERTY LINE
PAVED ROAD
GRAVEL ROAD
SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET



WOODRUFF ROAD
BROOK
RESERVATION BOUNDARY
NEW JERSEY NATIONAL GUARD FACILITY
BORDEN
BR.
SUCCESS
BOMARC Missile Site
Shelter 204
ELISHA BR.
NAVAL
OCEAN COUNTY HWY. NO. 539
NAVAL MILITARY RESERVATION BOUNDARY
HORNERSTOWN ROAD
BOUNDARY
SCALE 1:24000
0
1 MILE
1000
2000
3000
4000
5000
6000
7000 FEET

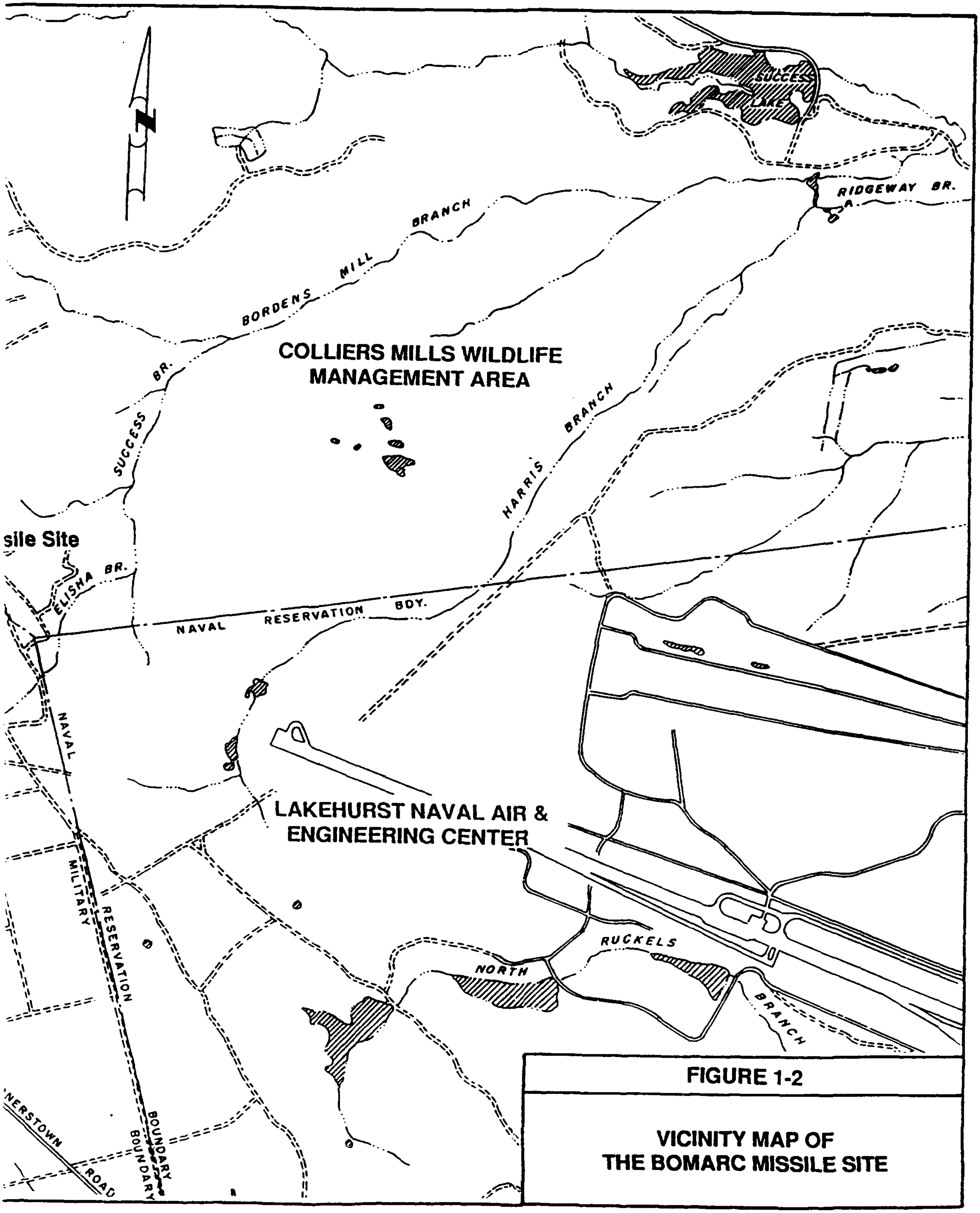


FIGURE 1-2

VICINITY MAP OF THE BOMARC MISSILE SITE

3-3

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In 1958, the 46th Air Defense Missile Squadron (ADMS) from McGuire AFB was authorized to use approximately 220 acres of land on the Fort Dix property for the construction of a missile facility. It ultimately housed two models of BOMARC missiles, the liquid-fueled Model A and the solid-fueled Model B.

The Liquid-Fueled BOMARC Interceptor Missile Model A (IM-99A), with an MK-40 nuclear warhead, was a supersonic ground-to-air weapon designed to destroy attacking aircraft and airborne missiles. The missile was 45 feet long with a wing-span of over 18 feet. It was a liquid-fueled rocket, using JP-X (jet fuel plus hydrazine), and an oxidizer. The nuclear warhead contained tritium and plutonium. The missile had a range of approximately 200 miles. The BOMARC IM-99A was phased out of operation during 1964. The Solid-Fueled BOMARC Interceptor Missile, Model B (IM-99B), was similar to the IM-99A except that it incorporated a solid-fuel rocket engine which gave the missile a greater range than the IM-99A.

The missiles were housed in individual, above-ground launcher shelters on a constant combat-ready basis. Upon receiving the alert signal, the shelter roof slid back and the missile was raised on its erector arm to its vertical launching position. The missiles were retired from active service and McGuire's BOMARC facility was closed in 1972. The missiles and warheads were removed from the shelters prior to closing.

1.1.2 BOMARC Missile Site Accident History

On June 7, 1960, an explosion and a fire occurred in BOMARC Missile Shelter 204. The force of the explosion destroyed portions of the shelter roof, caused flames to rise to 20 feet, and caused black smoke to blanket the area. At the time of the fire, a north-northeast wind of two to eight knots blew the smoke into the surrounding areas. Some of the plutonium released by the fire may have been carried aloft by the northeasterly wind, and dispersed from the BOMARC Missile Site.

The Air Force radiation surveys indicate that a substantial amount of plutonium was exhausted from Shelter 204 during the incident. The wall contamination results clearly show that uncontaminated air entered the shell of the structure from the north and northeast as these wall areas were uncontaminated. The air traveled southward towards the fire, and was exhausted in the southwest quadrant. Some contaminated exhaust was circulated around the lower level of the structure shell, and contaminated the lower walls on the east and west sides. The contaminated exhaust appears to have exited the building at the north half of the west wall and at the midline of the east wall. Substantial amounts of contamination were also detected on the upper surfaces of an "I" beam, which supports the roof structure, upwind from the source of plutonium.

The fire burned uninhibited for about 30 minutes. As part of the fire fighting activity, the area was sprayed with water from the fire hoses for approximately 15 hours. As a result, plutonium-contaminated water flowed under the front door of the Missile Shelter 204, down the asphalt apron and street, and into the drainage ditch leading outside the site boundary. An earthen dam was constructed across the ditch to contain the contaminated water. The drainage ditch runs in a southerly direction from Shelter 204, and parallels the site boundary fence for several hundred feet before it enters an underground culvert and crosses underneath Ocean County Route 539.

From this point, the culvert opens into a sandy ditch that eventually flattens into a wooded area.

Although no nuclear explosion took place, the nuclear warhead, which contained bottled tritium and plutonium, was burned and partially melted. The missile was destroyed, and the missile shelter was badly damaged. The oxidizer tank was displaced yet remained intact. The residue from the burning warhead contaminated the concrete floor. In addition to the severely damaged roof, the floor and concrete walls were pitted by flying fragments of the helium and fuel tanks. The steel roof beams were also deformed, and the shelter walls received heat damage.

The tritium bottle was found to be in good condition. The valve of the tritium bottle was removed, and both the valve and the bottle were sent to the Los Alamos National Laboratory in New Mexico. The remains of the warhead and all residue from the floor were placed in plastic bags, and then placed into sealed cans for disposal. The nuclear material was separated by grade. Shortly after the 1960 missile accident, seven containers of plutonium were recovered by explosive ordnance disposal personnel. Initially the containers were sent to Medina Base, San Antonio, Texas. The containers remained at the Medina Base until approximately 1965 when they were transferred to the Department of Energy (DOE) Pantex facility. The containers remained at Pantex until sometime in 1979 to 1982. The DOE conducted measurements of the recovered material during that period. The amount of plutonium in the warhead remains classified. However, DOE and Air Force scientists prepared an unclassified account of the disposition of the recovered material during that period. The account is provided as Volume 2, Appendix 2-5 of this EIS. The account indicates that the estimate of the upper limit of the plutonium that could have been left on-site is 300 grams.

The missile launcher is believed to have been removed from Shelter 204 shortly after the accident. However, its whereabouts remain unknown and no verified records indicating the manner or location of its disposal are known to exist. Air Force procedures in effect at the time of the accident would have included removal of contaminated debris from the shelter for disposal as waste. Existing records indicate disposal of additional radioactive waste from the site at the Idaho National Engineering Laboratory. Records also indicate containment measures were applied to the missile shelter and the asphalt apron but are silent as to the launcher.

In June 1960, air samplers were placed downwind of the accident site. The area was checked, and monitoring equipment was installed. During the fire, tar had melted and spread in a thin layer on sections of the floor of Shelter 204. Several sections of the floor containing tar showed radiation readings of over two million counts per minute (cpm). The level in the center of the road outside the shelter was also two million cpm.

The entire area was again washed down with water and then allowed to dry. Presumably, the wash water drained into the drainage ditch. Also in June of 1960, after the area was completely dry, the inside of the shelter was spray painted in order to shield alpha radiation emissions. The outside area was also painted. A total of 110 gallons of paint was used. After the paint had dried enough to walk on, radioactivity readings were again taken. Areas that had previously shown two million cpm then showed zero due to the shielding effect of the paint layer on alpha radiation emitted by the plutonium. Some of the fringe areas showed readings of 50 to 500 cpm.

Later in the month of June 1960, 4 inches of reinforced concrete were poured over the asphalt apron in front of Shelter 204 in an effort to fix the plutonium contamination under a protective overburden. In addition to this, two inches of asphalt were placed along the bottom of the drainage ditch located inside the site boundary fence. An additional 2 inches of concrete was added to a small portion of the shelter apron area in 1967, covering the manhole access to the communication and power pits, proximate to Shelter 204. The pit area inside Shelter 204 was filled with soil excavated from the rear of the shelter.

1.1.3 Summary of RI/FS Activities (Extent of Contamination)

Since 1960, numerous radiation surveys have been conducted around the BOMARC Missile Site. The Air Force has conducted surveys since 1967. In 1973, the Health Laboratory was directed by the Department of the Air Force to initiate an annual survey program. Surveys have also been conducted by the Army Environmental Hygiene Agency, the U.S. Army Radiation Team, Ballistics Research Laboratory, EG&G Inc., and others in recent years.

An RI/FS for the BOMARC Missile Site was completed during 1989-1992. The RI/FS consisted of an RI, a baseline risk assessment, and an FS, each of which is described briefly below. More details on the RI, FS, and baseline risk assessment are given in the RI/FS report (The Earth Technology Corporation, 1992).

The RI for the BOMARC Missile Site was conducted in order to determine the distribution and magnitude of plutonium and americium contamination in site soils, surface water, groundwater, air, and structural materials. This was done through a combination of background research on site characteristics, history, and sampling/analysis of soil, surface water, groundwater, air, and structural materials on-site.

The baseline risk assessment was performed for the BOMARC Missile Site in order to evaluate the potential threats to human health and the environment posed by radioactive contaminants on-site. The baseline risk assessment is used to quantify the risks to human health and the environment in the absence of remediation, and to determine the need for remediation. The results of the baseline risk assessment indicate that risks posed by contaminants on-site are sufficient to warrant site control or remediation.

1.2 Purpose

The overall objective or purpose of proposing to take action at the BOMARC Missile Site is to provide protection to human health and the environment. The proposed action is to affirmatively address the radioactive contamination at the site.

1.3 Need

Since the fire, the Air Force has maintained, monitored, and restricted access to the site. While site controls fulfill the Air Force's objectives of protecting human health and the environment; the information presented in the RI/FS and EIS will provide the basis for determining if there is a need for the Air Force to pursue a different course of action at the BOMARC Missile Site.

1.4 Decision to be Made

This EIS has been prepared as a tool to assist the Air Force in making a decision as to how to best address radioactive contamination at the BOMARC Missile Site. For more than thirty years, the Air Force has maintained and monitored the BOMARC Missile Site; and will now decide whether to continue existing practices by selecting the NEPA No Action alternative, or to select one of the other reasonable alternatives analyzed in this EIS.

Of the alternatives presented in Section 2.0 of this EIS, the Air Force has identified the Off-site Disposal Alternative with disposal at a DOE low-level radioactive waste disposal site as the Preferred Alternative. There are however, a number of issues that may impact the Air Force's ability to make an independent decision on the BOMARC site. Because of this, the possibility exists that the Air Force would be forced to select the NEPA No Action Alternative.

There are currently only three operating commercial low-level radioactive waste disposal facilities in the nation licensed to receive the radioisotopes present as contamination on the BOMARC site. They are the Chem-Nuclear facility in Barnwell, South Carolina, and the U.S. Ecology facilities in Beatty, Nevada, and Hanford, Washington. An additional facility licensed for disposal of bulk materials and operated by Envirocare, Inc. located in Utah, has applied for an amendment to its license for plutonium and may also be available.

The Air Force prefers to dispose of the BOMARC waste in a DOE low-level radioactive waste facility because disposal costs are a significant factor. Costs for disposal at a commercial site are significantly greater than disposal at a DOE facility. The cost of disposing of BOMARC Missile waste at the U.S. Ecology Hanford site is estimated to be $24 million where as disposal at the DOE's Nevada Test Site is estimated to be $7 million.

The Air Force has no firm response from the DOE as to whether or not DOE will accept the BOMARC waste. It is the Air Force's understanding that the DOE will not consider acceptance of the waste unless the Air Force has been refused disposal permission at all available commercial sites. The Air Force believes it is currently in good standing with the commercial waste sites and has applied for permission to dispose of the BOMARC waste at all four commercial facilities. No response has yet been received from any of the four commercial sites.

The issue that will most impact the Air Force's ability to make an independent decision is the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) governing interstate shipment and disposal of radioactive waste. The LLRWPAA places the burden for low-level radioactive waste disposal with the individual states, or with compacts of states, and establishes a schedule for phased implementation. This act has already increased the cost of disposal at the licensed commercial sites through its provisions allowing currently sited states to levy waste surcharges. Costs are projected to escalate even more as states and compacts set fees to support their sites' operations. A more immediate issue affecting any decision is the scheduled closure of the commercial sites on January 1, 1993. On that date, another provision of the LLRWPAA takes effect that closes existing commercial sites to generators outside the state or compact in which the site is located. As state and compact agreements now stand, waste generators in New Jersey will have no access to existing sites even if they remain open to member states within the sites' compacts.

The Air Force cannot make a decision on the BOMARC Missile Site that involves disposal until sites willing to accept the waste have been identified and costs analyzed for effectiveness. The NEPA No Action alternative would be implemented by default if permission is not secured or if disposal options are not cost effective.

In the event NEPA No Action is implemented, radioactive contamination would remain in-place, and access controls and environmental monitoring would continue until such time that a viable, economically feasible off-site disposal facility becomes available.

1.5 Scoping Process

In accordance with Air Force guidance and pursuant to the requirements of the National Environmental Protection Act (NEPA) of 1969 and 40 Code of Federal Regulations (CFR) 1500, a notice of intent to prepare an EIS concurrently with an RI/FS for the BOMARC Missile Site, McGuire AFB, New Jersey, was published in the *Federal Register* on December 22, 1988. Notification of public scoping was also made through local media as well as through letters to federal, state, and local agencies and officials, interested groups, and individuals. The significant issues identified in the notice of intent, relative to the EIS, included:

- The distribution of radioactive contamination around the site
- Extent of contamination resulting from air dispersion
- Migration of contaminants through aquifers and surface runoff water
- Physical transport of contaminants by humans and animals
- The effect of the incident on the ecosystem
- Efficiency of post-accident management efforts to reduce hazards through decontamination, containment, or removal of hazardous or potentially hazardous materials
- The appropriate degree of cleanup consistent with public health and welfare and present and future uses of the site.

A public scoping meeting plan (Battelle Columbus Division, 1988) was prepared. Two public scoping meetings for the EIS and RI/FS were conducted on January 11, 1989. The first meeting, designated for Federal, state, and local officials was held during the morning at McGuire AFB. The second meeting was targeted for the general public and was held that evening near the base in the Jackson Township Municipal Building. At the meetings, formal presentations were provided detailing the background on the BOMARC Missile Site and explaining the processes to be used to prepare the RI/FS and EIS documents.

Following the summary of the formal presentation, comments were solicited to insure all public concerns could be identified and incorporated into the scope of the EIS. The public was assured that in evaluating potential alternatives, primary consideration would be given to meeting the requirements of Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA)/Superfund Amendments and Reauthorization Act of 1986 (SARA) and NEPA. The public was also assured that alternatives would be evaluated in terms of the degree of protection provided and the potential for reduction of mobility, toxicity, or volume (MTV) of contaminants. In addition to verbal comments received during the scoping meeting, additional written agency comments were provided by the U.S. Fish and Wildlife Service (USFWS), the State of New Jersey Department of Environmental Protection and Energy (NJDEPE), and the U.S. Department of Health and Human Services, Public Health Service. Comments and concerns expressed at the scoping meeting and received in writing are summarized below:

- The potential for airborne transport and deposition of radiation over the adjoining townships
- The potential for active transport of radioactive plutonium or americium by small animals living on the site
- The potential for release of plutonium through surface and groundwater media
- The potential for any removal action to disturb the site and release radiation
- The problems associated with identifying a waste depository and the risk of transporting plutonium-contaminated soils and debris
- The difficulty in ensuring that the BOMARC Missile Site would not be disturbed as long as the health threat from radioactive contaminants exists (due to the extremely long half-life of plutonium, the health threat may exist in perpetuity)
- The concern that follow-on studies should be conducted on individuals involved in the fire suppression effort and subsequent clean-up efforts
- The need for a complete faunal survey and an assessment of the potential for biological uptake of plutonium contamination
- The need to sample potentially exposed resident wildlife.

All of the comments and concerns, with one exception, have been addressed in this EIS. Issues related to the status and condition of individuals who were involved in the fire suppression effort and subsequent clean-up activities which occurred in the 1960s are not related to or affected by any of the alternatives considered in this EIS. No studies of this nature were conducted as part of the RI/FS or EIS process.

1.6 Public Hearing and Comments

The EIS was filed with the Environmental Protection Agency (EPA) on September 6, 1991. A public notice of the EIS filing was published in the Federal Register during the week of September 13, 1991. A public hearing was held in the New Hanover Township, Municipal Building in Cookstown, New Jersey on October 3, 1991 to solicit oral and written comments on the EIS. A full transcript of the Public Hearing is included in Volume 2 of this EIS (Appendix 2-1). A 45 day public comment period was provided. A complete set of written comments is provided in Volume 2 (Appendix 2-2). Public comments have been carefully evaluated and have been incorporated into the Final EIS. The EPA and the New Jersey Department of Environmental Protection requested an interagency meeting to discuss some of the major issues and provide clarification of the written comments provided by these agencies. A meeting was held on January 9, 1992 and the EPA Edison facility in Edison, New Jersey.

The general consensus, expressed at the Public Hearing and in the written comments, was that, the Air Force should select one of the two active remedial alternatives (Off-site Disposal or On-site Treatment). There were several commentors, however, who did not favor intrusive actions at the site and expressed a preference for leaving things as they are currently (NEPA No Action or Limited Action Alternatives). In addition, two recurrent issues were identified in multiple written comments:

- Verification of the quantity of residual plutonium at the site.
- Methodology for the baseline radiological assessment.

Shortly after the missile accident, seven containers of plutonium were recovered by explosive ordnance disposal personnel. The DOE conducted measurements of the material which indicated the upper limit of the plutonium that could have been left on-site is 200 to 300 grams. An unclassified account of the disposition of the material is provided as Volume 2, Appendix 2-5 of this EIS.

The appropriate level of cleanup is the critical issue related to Off-site Disposal and On-site Treatment Alternatives. To clarify the cleanup level proposed in this alternative and to answer a number of questions presented by EPA and the NJDEPE, the methodology utilized for the RI/FS and EIS was modified. The modifications to the approach used in the radiological assessment are summarized below:

- A later version of the computer model (RESRAD Version 4.1) was used.

- Guidance on non-homogenous distribution of contamination was incorporated into the model runs.

- The exposure parameter values in EPA's OSWER Directive 9285.6-03 was used.

- The value used for mass loading was reevaluated and resulted in the use of the RESRAD default value that is two times higher than previously used.

The soil cleanup level developed in the RI/FS is based directly on the output from the computer code. An effective dose equivalent of four millirem per year was used as the dose limit for derivation of the cleanup level by the code. This dose represents an acceptable lifetime cancer risk of less than 10^{-4} (Burley, 1990). The plutonium-239 (^{239}Pu) cleanup criterion that was derived is 8 pCi/g (Appendix J in TETC, 1992). A detailed explanation of the approach used in the radiological assessment supporting the derivation of the soil cleanup criterion is outlined in Volume 3 (Appendix 3-8).

1.7 Relevant Federal, State, and Local Statutes, Regulations, and Guidelines

The EIS was prepared in compliance with NEPA, PL 91-190 (42 United States Codes (USC) 4321 et seq.), and implementing regulations (40 CFR 1500 et seq.) established by the Council on Environmental Quality.

This document addresses the relevant sections of the Clean Air Act (CAA), Clean Water Act (CWA), Threatened and Endangered Species Act, National Historic Preservation Act, as well as state environmental laws and local regulations and ordinances. The above acts and regulations are discussed in the resources sections to which they apply. The RI/FS completed for the site contains a complete analysis of Applicable or Relevant and Appropriate Requirements (ARARs) as they relate to each of the alternatives under consideration. That discussion is summarized in Section 4.7 of this EIS and is provided in full in Section 5.0 of the RI/FS.

Two alternatives, NEPA No Action and Unrestricted Access, would not involve new construction and would not require licensing or permitting. Two alternatives, Off-site Disposal and On-site Treatment, would require excavation and off-site disposal of contaminated materials. Transportation off-site would require compliance with 49 CFR Parts 170-189. State permits may include an Air Permit to Construct and a temporary Air Permit to Operate. Control devices such as vacuums and High-Efficiency Particulate Air (HEPAs) would also require a permit. Implementation of this alternative would include a permit inventory and review, to ensure that all applicable Federal, State, and local permits are obtained during the remedial design phase and prior to any remedial action activities.

In addition, some states have licensing requirements related to transportation that are more stringent than the Federal requirements. The State of New Jersey requires a Certificate of Handling. Additional state requirements that would have to be met depend on the route that is selected. The Limited Action Alternative would also require off-site transport of contaminated materials if the missile launcher is located. The same Federal and state requirements would apply.

1.8 Preparation and Organization of this EIS

The EIS, as well as the RI/FS, have been prepared using a systematic, interdisciplinary approach to evaluate the affected environment and determine the environmental effects of the alternatives under consideration.

The Final EIS is 3 volumes. This volume (Volume 1) contains the following sections. Section 1.0 provides background and outlines the purpose and need for the proposed action. Section 2.0 consists of detailed descriptions of each of the five alternatives and a summary comparison of the alternatives. Section 3.0 consists of a description of the affected environment; baseline conditions of the site are described, including geology and soils, hydrology, meteorology and air quality, biology, land use, transportation, and demographics. A radiological characterization of the site and environs is also provided as part of Section 3.0. In Section 4.0, environmental consequences are assessed for each of the five alternatives. Mitigation measures for each alternative are described, and ARARs are discussed. Other discussions include: energy requirements and conservation potential; adverse environmental effects that cannot be avoided;

relationship of short-term to long-term productivity; and irreversible or irretrievable commitment of resources. Section 5.0 includes a list of preparers. Section 6.0 consists of a list of agencies and persons consulted. Section 7.0 is a distribution list and Section 8.0 contains references. An index to the EIS is also provided.

Volume 2: Public Hearing, Comments, and Consultation Letters contains Appendices 2-1 through 2-6. These appendices include transcripts of the Public Hearing, all public comments, comment summaries and responses and indexes to the comments and commentors. In addition, consultation letters to radioactive waste disposal facilities and to the New Jersey State Historic Preservation Officer.

Cultural resources were not evaluated in detail in the EIS for a number of reasons. The site was regraded, excavated and heavily developed to accommodate the series of missile shelters and ancillary support facilities that were constructed. The site was intensively used for an extended period of time. Archeological features, if present, would be substantially disturbed. Surface artifacts have not been reported in the areas suspected to be contaminated. The contaminated missile shelter and other shelters are not structurally unique. Whereas the shelters may have historical value, contamination at the site would render public access to the site problematic. In order to confirm that the Air Force position is correct, the Air Force has initiated Section 106 consultation with the New Jersey State Historic Preservation Office.

Volume 3: Methodology Development contains Appendices 3-1 through 3-8. These appendices provide a summary of the methodologies and approaches utilized to conduct the environment analyses for each resource area provided in Volume 1.

1.9 Changes to the EIS

As a result of the public comment process, the text of this EIS has been revised, when appropriate, to reflect concerns expressed in public comments. The responses to the comments in Volume 2 indicate the relevant sections of the EIS that have been revised. The primary changes include the following:

- The cleanup criterion developed in the RI/FS was changed to 8 pCi/g. The risk analyses were revised public and occupational health sections were substantially revised.
- Information was provided regarding disposition of residue from the accident.
- The Air Force identified the Off-site Disposal Alternative as the preferred alternative.
- The Air Force has initiated Section 106 consultation with the New Jersey State Historic Preservation Officer. Correspondence is included in Volume 2 Appendix 2-6.

- Supplemental information regarding the cost of each alternative was incorporated into the EIS.

- The Air Force has initiated consultation with U.S. Department of Interior Fish and Wildlife Service.

SECTION 2.0

ALTERNATIVES CONSIDERED FOR ACTION

2.0 ALTERNATIVES CONSIDERED FOR ACTION

The Preferred Alternative (Off-site Disposal) and four other alternatives are described in this section: Unrestricted Access, NEPA No Action, Limited Action, and On-site Treatment. A three phase process was used to select these five alternatives. In Phase I of the FS, remedial objectives were identified, including health- and regulatory-based cleanup criteria. An array of remedial technologies potentially applicable to the site were identified. These technologies were screened to eliminate those that were clearly not feasible due to waste characteristics, site conditions, or technical requirements. Six alternatives were identified in Phase I: an unrestricted access alternative; an existing conditions alternative, a limited action alternative, an on-site containment alternative, an on-site treatment alternative, and an off-site disposal alternative (these alternatives will be further described below).

In Phase II of the FS, the six alternatives were screened according to three criteria: public health/environmental impacts, technical feasibility, and cost. As a result of the Phase II screening, the on-site containment alternative was eliminated from consideration. This alternative would have involved redepositing and capping contaminated materials on-site. Since New Jersey State regulations prohibit disposal or storage of radioactive waste in the Pinelands, this alternative was eliminated from consideration as a reasonable alternative and was not evaluated in this EIS.

In Phase III of the FS, the remaining five alternatives were evaluated in detail. The analyses included technical feasibility, environmental effects, public health effects, institutional requirements, cost, and state/public acceptance. These five alternatives, with the exception of the Unrestricted Access Alternative, were determined to constitute reasonable approaches. The alternatives were refined and mitigations were developed to address the issues that were identified during the scoping process. The Air Force issued the Draft EIS in August of 1991. The Draft EIS provided a comparative evaluation of the potential environmental consequences that might result from implementation of the alternatives. Based on public comments, and consistent with the Air Force's proactive approach to environmental restoration, the Off-site Disposal Alternative was identified as the Preferred Alternative. Based on public comments the approach used in the radiological assessment and the methods used to determine a cleanup level appropriate for the preferred Off-site Disposal Alternative were modified. All five alternatives are summarized below:

- **Unrestricted Access**: This alternative represents a scenario under which there is a loss of Air Force control over the BOMARC Missile Site. Although not considered reasonable by the Air Force, it was evaluated as a worst-case scenario to inform the public of the environmental impacts associated with a "loss of control" scenario which may occur due to the 24,400-year half-life of the radioactive material. Contaminated materials would be left in place. Current management practices, which include access controls, monitoring, and maintenance would be discontinued.

- **NEPA No Action**: This alternative is identical to the existing conditions alternative described in the RI/FS. Under this alternative, there would be a continuation of access restrictions, maintenance of existing containment structures, and continuation of monitoring site conditions.

- **Limited Action**: Under this alternative, there would be a continuation of access restrictions and site monitoring, maintenance of existing containment structures. This alternative would entail searching for the missing missile launcher and metal debris from Shelter 204. Five areas with magnetic anomalies have been identified as possible burial localities; these areas would be excavated in search of the missing items. Subsequent activities may include removal of the contaminated materials from the site.

- **Off-site Disposal**: Under this alternative, contaminated soils and structural materials, including the missile launcher, if located, would be removed from the site and disposed off-site in an appropriate radioactive waste disposal facility.

- **On-site Treatment**: Under this alternative, contaminants from soils and structures including the missile launcher, if located, would be removed using on-site physical treatment processes and disposal of the radioactive contaminants in an appropriate off-site radioactive waste disposal facility.

The five alternatives evaluated in this EIS are discussed in greater detail in the sections that follow. Mitigation measures which would be incorporated into each alternative to lessen the potential environmental and human health impacts associated with implementation are summarized here and discussed in detail in Section 4.0.

2.1 Unrestricted Access Alternative

The Unrestricted Access Alternative assumes that control of the site is lost at some time in the future. This assessment is a hypothetical worst-case scenario. This scenario assumes that contaminated materials are left in place and current management practices, which include access controls, monitoring, and maintenance, are discontinued. To evaluate the potential public health impacts of this scenario, a series of assumptions were developed and are discussed below.

To estimate the upper bound (worst-case) for doses to an intruder, it was assumed that long-term institutional control of the site would not exist and members of the public would have unrestricted access to the site at some time in the future. In order to assess the intruder scenario, a construction/resident scenario (one used by the Nuclear Regulatory Commission [NRC]) for waste disposal assessments, was adapted.

The construction/resident scenario consists of two parts. The first part of the construction/resident scenario assumes the discovery of the buried missile launcher during excavation. Potential doses from excavation work are estimated using a scenario adapted from one used by the NRC for waste disposal assessments.

The NRC scenario (NRC, 1981) assumes that the intruder contacts the disposed wastes while performing excavation work associated with the construction of a basement for a house. It was assumed that there are two sources of contamination: existing surface soil contamination as characterized by site surveys and contamination associated with the buried launcher. It is further assumed that there was no cover over the contaminated soil.

It was assumed that the missile launcher is buried on-site. For this worst-case analysis, the contamination associated with the buried missile launcher was assumed to consist of about 18.4 Ci (300 g) of plutonium and 3.1 Ci of americium residue. Most of this contamination was assumed to be fixed to the surface of the launcher structure. The radioactivity associated with the launcher was assumed to be 90 percent fixed surficial contamination and 10 percent removable contamination. The removable contamination was assumed to be 90 percent large, nondispersable particles and 10 percent particles with the same size distribution as surface soils. Removal, handling, and sectioning of the launcher was assumed to uniformly contaminate all the soil within 0.5 m of the launcher (100 m^3 of soil).

The second part of the construction/resident scenario consists of an agricultural/resident scenario. This scenario provides upper-bound estimates of potential doses for a hypothetical maximally exposed individual. It was assumed that the agricultural resident lives continuously in a house on the BOMARC Missile Site and consumes only foods grown in areas with the maximum air concentration. To provide an upper bound for potential doses, it was assumed that all the radioactivity on the site is available for transport through the environment. That is, the barriers presented by existing concrete and asphalt covers have been neglected. The intruder was assumed to be exposed to both the existing surface soil contamination and an additional amount of contamination resulting from excavation of the buried missile launcher. Contaminated soil excavated during construction activities of the intruder-construction scenario was assumed to be used as backfill around the house.

2.2 NEPA No Action Alternative

The operational procedures associated with the NEPA No Action Alternative are currently implemented at the site. The NEPA No Action Alternative consists of continuation of operational procedures designed to protect human health and the environment by accomplishing the following:

- Restricting public access to the site
- Preventing deterioration of existing containment structures
- Monitoring the distribution and potential migration of plutonium and americium on-site and off-site
- Preventing disturbance of the site.

These goals would be accomplished through continued implementation of the following actions:

- Maintenance of fencing and signs and including installation of new fencing
- Quarterly visual inspections

- Maintenance of concrete apron
- Radiological surveys
- Maintaining government control of the site.

Fencing and signs would continue to be used to preclude access by the public. Fences would be 6 feet high, and topped with barbed or concertina wire. Existing fences would be replaced as needed. Appropriate warning signs (no trespassing and radiological hazard signs) would be posted on the fence at 50-foot intervals. In order to continue the policy of restricting access to contaminated areas, an additional 2,750 linear feet of fence would be added to the existing 2,200 linear feet of fence and an additional 100 no trespassing/radiological hazard signs would be required.

Quarterly visual inspections would be used to document site conditions. The condition of fencing and signs would be inspected to ensure site security. The condition of contaminated media would be inspected, and evidence of deterioration or damage would be noted. Corrective actions would be recommended and executed if conditions warrant.

Maintenance of the concrete apron and the drainage ditch would continue to be performed on an as-needed basis. The cement overlayer would be patched and repaired as required. Asphalt would be sealed and plants removed on an annual basis. Maintenance operations would generate an estimated two 55-gallon drums of low-level radioactive waste (LLW) (average activity less than 100 nCi per g) annually that would require disposal.

Radiological surveys would be conducted to verify that contaminants are not migrating off-site. Sampling would include selected on-site groundwater wells, stream sediments in the site drainage pathway, and soils from both on-site and off-site. Sampling techniques would include a combination of sample collection/laboratory analysis and in-situ survey techniques. It is estimated that the radiological surveys would generate four 55-gallon drums of potentially radioactive (less than 100 nCi per g) wastes requiring disposal.

Radiological surveys would consist of:

- Sampling of 10 on-site groundwater-monitoring wells
- Collection of 20 sediment and 40 soil samples from near-site locations
- Field Instrument for the Detection of Low Energy Radiation (FIDLER) surveys of near-site locations
- Analysis and write-up of results.

The site would be kept under government control so that contaminated media are not disturbed in the future. If the government maintains possession of the site, deed restrictions would not be necessary. Otherwise, deed covenants restricting land use would be required.

Mitigations would be implemented during on-site activities to control soil erosion, decrease fugitive dust emissions, and lessen occupational and public health impacts. A new H&SP would be developed for maintenance activities. Radiation surveys would be conducted.

2.3 Limited Action Alternative

The Limited Action Alternative is nearly identical to the NEPA No Action Alternative except that it includes a search for a missile launcher which may be buried on-site. If located, the launcher would be excavated and disposed of at the Nevada Test Site.

The location of the missile launcher and metal debris material from Shelter 204 is currently unknown. A geophysical survey was conducted during the RI for the purpose of locating the missile launcher. The geophysical survey identified five magnetic anomalies on or adjacent to the BOMARC Missile Site that could represent sites that contain the missile launcher and metal debris. To determine if the anomalies do represent the missile launcher, excavation and visual inspection would be required. All five anomalous areas may have to be excavated in the attempt to locate the missile launcher and associated metal debris.

If the launcher is found, additional actions would be required. At present, the size, shape, and level of radioactivity of the launcher are unknown. The intense heat associated with the fire in Shelter 204 may have partially melted or deformed the launcher. Originally, the launcher was approximately 30 feet long and weighed an estimated 2 to 3 tons. The launcher may have to be sectioned to facilitate removal and transport. Since the launcher may be contaminated and the degree of contamination is unknown, the launcher would have to be surveyed with appropriate radiological survey equipment to document the degree of contamination.

Because soils surrounding the launcher may be contaminated, soils would be sampled and contained until receipt of sample analysis results. Sampling efforts would require analysis of approximately 40 soil samples for ^{239}Pu by alpha spectroscopy. After the launcher and surrounding soils are characterized with respect to radioactivity, the launcher and soils contaminated above relevant action levels would be excavated. The maximum expanded volume of soil that was estimated to be contaminated in the RI/FS was 100 yd^3. The volume of the launcher was estimated at 5 yd^3. Soils would be transported off-site to an appropriate licensed radioactive waste disposal facility. The launcher would also be transported off-site for disposal. All excavated areas would be restored to original grade, covered with topsoil, and replanted with species indigenous to the New Jersey Pinelands.

The Air Force has applied for radioactive waste disposal at all available commercial sites. Relevant correspondance is provided in Volume 2 of the EIS (Appendix 2-6). For this EIS, two radioactive waste disposal facilities have been evaluated. These facilities include U.S. Ecology's Hanford Site in Washington and the DOE's Nevada Test Site. These two facilities are representative of the types of radioactive waste facilities available (i.e., Hanford is commercially operated, whereas the Nevada Test Site is a government facility). Because disposal costs at commercial facilities are significantly greater than at government facilities, the Air Force's preferred disposal site is the Nevada Test Site.

Trucking has been selected as the preferred mode of transporting wastes to the Nevada Test Site. There are two main reasons to transport the wastes from the BOMARC Missile Site by truck rather than by rail or air: safety and the cost. The DOT and State regulations governing the transport of radioactive waste would be observed. The route selected would be the most direct and would use the interstate highway system to the maximum extent possible. The transport of radioactive waste by alternate modes of transport has been evaluated in other NEPA documents. Truck transport has generally been determined to be an acceptable mode. Rail and air transport would require two transfer points before reaching the Nevada Test Site:

1. The waste would need to be transported by truck from the site to a rail station or airport, and

2. The waste would need to be transported by truck from a rail station or airport near the Nevada Test Site.

There is no direct rail route to the Nevada Test Site (U.S. DOE, 1990). The choice of air carriers is limited because large quantities of nuclear materials cannot be shipped by air to high population densities. Most airports are centered in high population densities (U.S. Department of Commerce, 1977).

According to the U.S. Department of Commerce, truck transport is the most cost effective method of shipment. The unit cost of air transport is estimated to be substantially greater than the cost of truck transport. Either rail or air transport would require two additional transfers of waste material. The unit cost of rail transport is slightly lower than truck transport. However, rail transport would require two additional transfers of waste material which would increase cost and the potential for fugitive dust to escape to the environment.

In addition to the mitigation measures discussed for the NEPA No Action Alternative, the Limited Action Alternative would require additional excavation associated with searching for (and possibly locating) the missile launcher. Mitigation measures that would be used include: covering exposed piles of excavated dirt, restoring disturbed excavated areas, construction of perimeter controls around the excavated areas, fencing the threatened plants at the site, construction and use of a decontamination pad, limiting truck traffic during peak community hours, and development of a H&SP specific to excavation activities.

2.4 Off-site Disposal Alternative

The volume of contaminated material at the site is described in Section 3.1. The Preferred Alternative would involve excavation and off-site disposal of approximately 6,200 yd^3 of contaminated soils. An additional amount of concrete, asphalt and other contaminated debris would be sectioned, excavated and disposed of off-site in a licensed radioactive waste disposal facility. To determine the absolute volume of material that would be excavated a risk based cleanup level was developed. For soils the site specific goal for remediation would be 8 pCi/g.

Removal and off-site disposal would be a permanent source-control measure. This would consist of excavation of contaminated soils, demolition of structures, and transport/disposal by truck to a permitted off-site disposal facility. Off-site disposal facilities that were considered include the

U.S. Ecology facility in Hanford, Washington, and the Nevada Test Site. The Air Force's preferred disposal locations is the Nevada Test Site. Removal of contaminated materials would eliminate the long-term source for on-site or near-site exposure. Restoration of excavated areas by filling and regrading would be required and a soil sampling or in situ surveying program would be required to verify the vertical and lateral limits of excavation.

Different environmental media would be handled and packaged differently. On-site radioanalysis would be employed to limit the total amount of wastes designated for disposal as radioactive waste. In addition, separation of materials not requiring remediation from contaminated materials would be employed to limit the total amount of radioactive wastes. For example, on-site analysis would be used to scan concrete from Shelter 204 and the Concrete Apron/Drainage Ditch prior to final sectioning. Contaminated portions would then be sectioned away from uncontaminated portions. Uncontaminated materials would be left on-site. Handling procedures for each of the contaminated units are described below.

Shelter 204. Shelter 204 would be sectioned, scanned with an appropriate radiation detection instrument and/or alpha detector and containerized for off-site transport. Materials found to be below threshold limits established in the RI/FS would be left on-site. All demolition activities would be monitored using high-volume air samplers; data would be compiled at the end of each work-day. Engineering controls designed to minimize resuspension would be utilized. The maximum volume of waste material that would be disposed of estimated at 402 yd^3, and transportation of this would be by truck to one of the two disposal sites mentioned above.

Apron/Drainage Ditch. The concrete apron would be sectioned and scanned with an appropriate radiation detection instrument to separate uncontaminated material prior to off-site disposal of the contaminated fraction. Concrete found to be below threshold limits established in the RI/FS would be left on-site. The maximum volume of concrete that could require off-site disposal is 356 yd^3. There is an additional 1,120 yd^3 of asphalt cover in the drainage ditch with an expanded volume of 124 yd^3 that could require off-site disposal. All demolition activities would have engineering controls designed to minimize resuspension of radioactive contaminants, and all activities would be monitored using high volume air samplers. Transportation would be by truck to one of the two disposal sites mentioned above.

Utility Bunkers. Utility bunkers would be excavated, sectioned, scanned with an appropriate radiation detection instrument, and containerized on-site. The maximum volume that would require disposal as radioactive waste is estimated at 37 yd^3.

Contaminated Soil. Contaminated soil would be excavated using conventional excavation equipment. Continuous air monitoring would be performed in work areas, and engineering controls for dust suppression, such as spraying the soil with water, would be implemented. An estimated 6,200 yd^3 of soil would be excavated from areas shown on Figure 2-1. Soil would be containerized on-site, loaded onto trucks, and trucked to one of the two disposal sites mentioned above. All areas excavated would be restored to original grade, covered with topsoil, and replanted with species indigenous to the New Jersey Pinelands.

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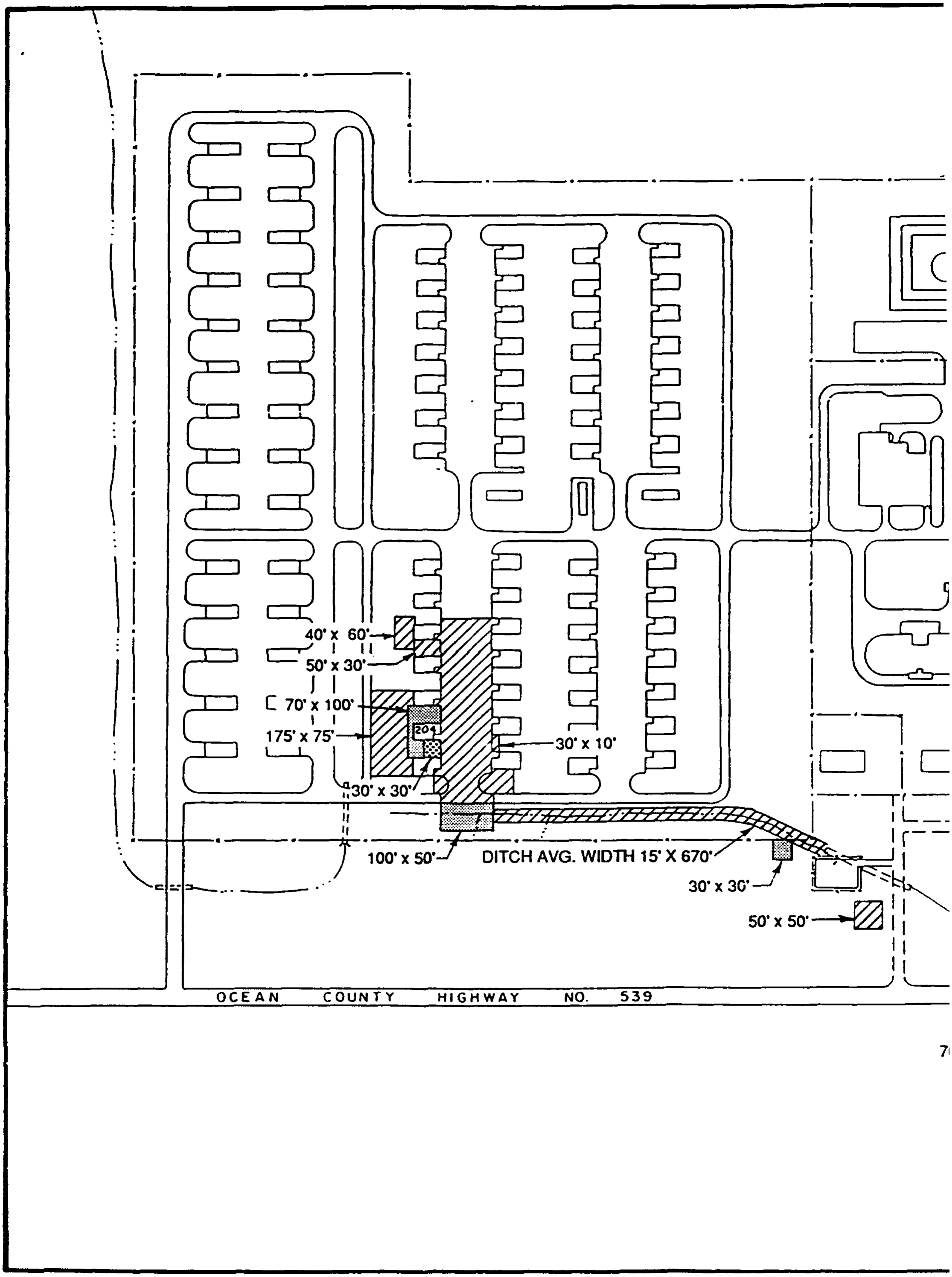
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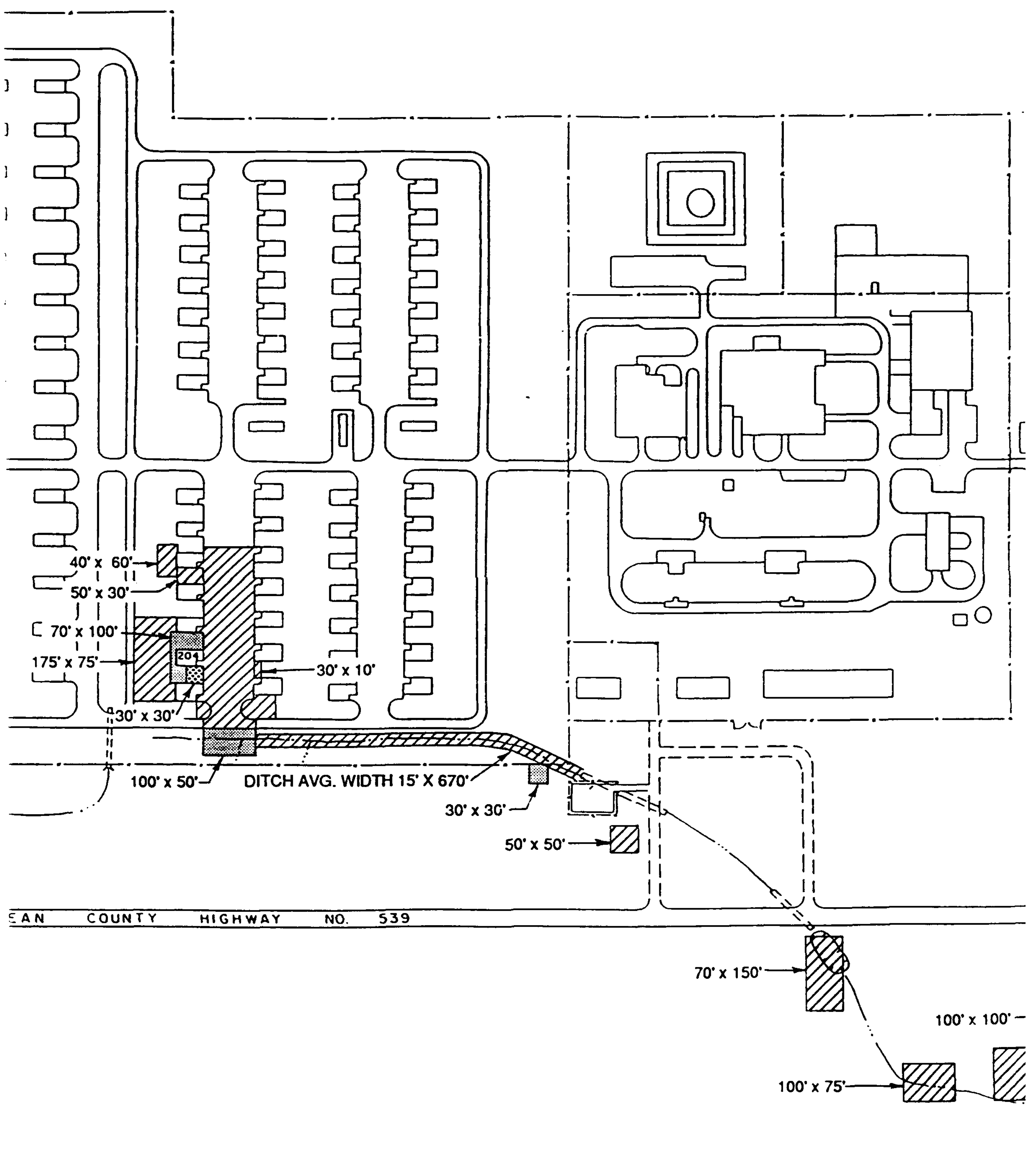

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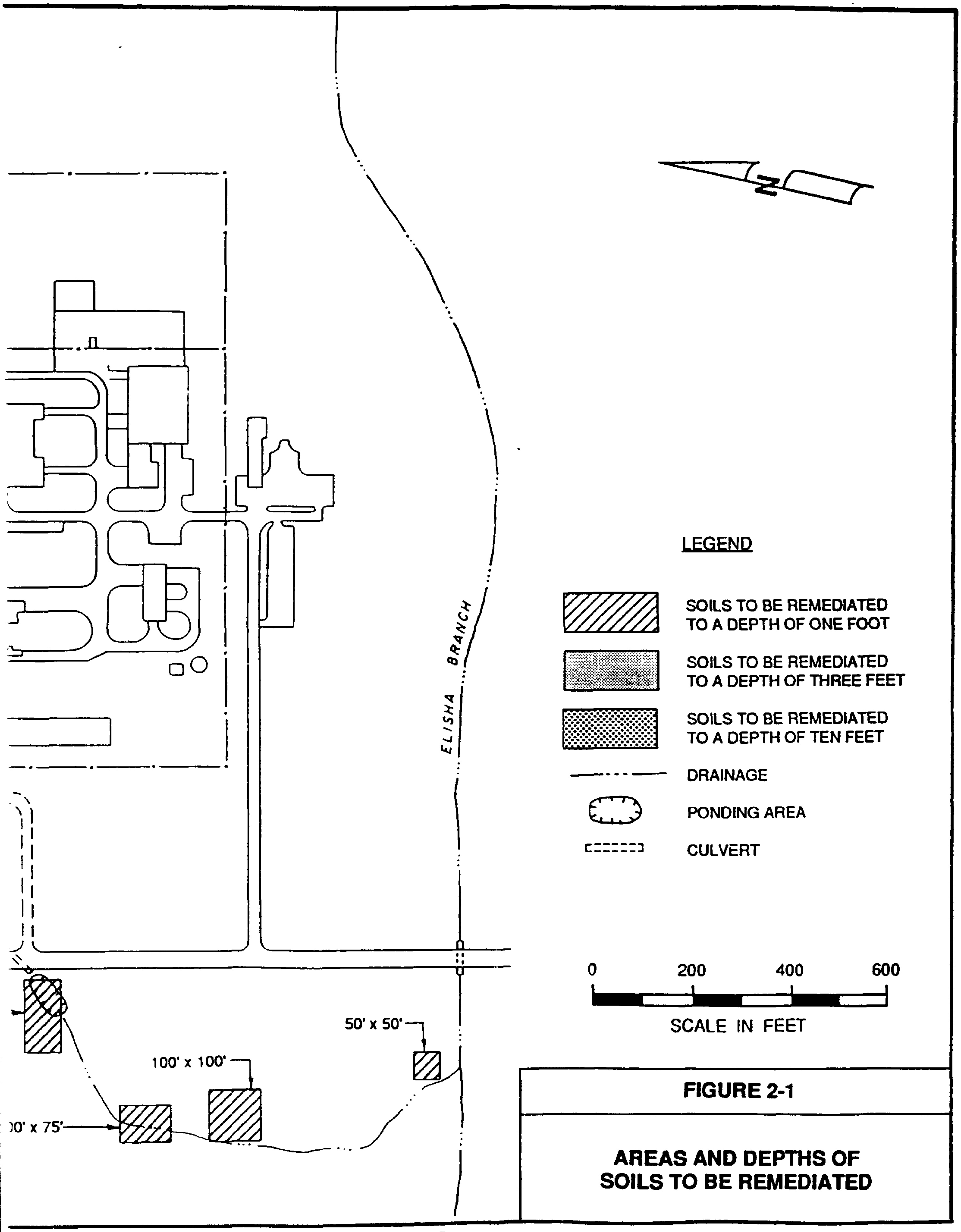

FIGURE 2-1

AREAS AND DEPTHS OF SOILS TO BE REMEDIATED

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Missile Launcher. The missile launcher and other metal debris would be excavated, as described in Section 2.3. The entire launcher, having an estimated volume of 5 yd^3 and an estimated weight of 2 to 3 tons, would require sectioning and disposal. All areas excavated would be restored to original grade, covered with topsoil, and replanted with species indigenous to the New Jersey Pinelands.

Disposal. The Air Force's preferred disposal location is the Nevada Test Site. Landfill technology is a proven, well-demonstrated technology that has been used for hazardous, municipal, and low level wastes. Landfilling more concentrated wastes may also occur on a case-by-case basis with approval from the NRC.

Implementation of the Off-site Disposal alternative would require engineering controls to prevent erosion/suspension of contaminants during excavation. Air samplers would be used to monitor activities. Additional mitigation measures that would be used include: covering exposed piles of excavated dirt, restoring disturbed excavated areas, construction of perimeter controls around the excavated areas, fencing the threatened plants at the site, construction and use of a decontamination pad, limiting truck traffic during peak community hours, and development of a H&SP specific to excavation activities. The Air Force has conducted IRP activities at the site in accordance with the National Contingency Plan (NCP). To implement this alternative, a site specific plan that would expedite remedial activities at the site would be developed. During the remedial design phase a complete mitigation plan would be developed. Performance standards would be developed and incorporated into the remedial action contract.

2.5 On-site Treatment Alternative

The On-site Treatment Alternative calls for removal of radioactive contaminants from soils and structures at the BOMARC Missile Site including the missile launcher, if located, through on-site physical treatment processes and disposal of the contaminants in an appropriate, licensed, off-site radioactive waste disposal facility. The Air Force's preferred disposal location is the Nevada Test Site.

The On-site Treatment Alternative involves physical removal of radioactive plutonium and americium from contaminated media on-site, concentration of the removed radioactive wastes, and shipment of the resulting concentrated wastes off-site for disposal. The treated decontaminated materials would be redeposited on-site.

The method of treatment that would be used depends on the type of contaminated material. There are three general treatment/handling methods that would be used prior to off-site disposal: (1) sectioning and surface-abrasion techniques; (2) use of the TRU-Clean® or similar sorting process; and (3) direct removal and off-site disposal. The first two methods involve physically concentrating radioactive materials under controlled conditions so that the amount of radioactive wastes sent off-site for disposal is minimized. Extreme care would be utilized to ensure that wastes are not concentrated to the point that radioactivity exceeds 100 nCi per gram (g). Wastes with activities above 100 nCi per g may not be disposed of in either of the off-site facilities that were considered.

The surface-abrasion methods address contaminated metal, concrete, or paint on metal or concrete. Sections of the metal or concrete would be removed and taken to an on-site treatment facility where surface-abrasion techniques would be employed to remove the contaminated surfaces of the pieces of concrete or metal. This method requires that the removed sections remain structurally intact, and thus cannot be used on contaminated asphalt.

Concrete saws would be used to section concrete materials. Conventional construction saws would be modified to incorporate containment mechanisms to preclude the spread of contaminants. The cutting blade would be cooled by circulated water, which would require collection and containment.

Sectioning of concrete would be done outdoors under strict engineering controls designed to prevent resuspension of contaminated particulates. If water or other fluids are used to lubricate or cool sectioning equipment, the fluids would be collected and/or contained. If dust or particulates are generated, a vacuum blower would be used to direct the dust through a HEPA filter to capture the particulates. Air samplers for monitoring would be placed near sectioning activities.

A number of surface-abrasion techniques could be employed. Various options would be tested to determine the most effective technique(s). The following surface-abrasion techniques are possible:

- **Spaller/Scarifier/Scrubber/Impactor Processes**: These would be used to mechanically break down the surfaces of the concrete walls and floors of buildings.

- **Sandblasting**: Materials such as silica sand, Al_2O_3, B_2O_3, glass beads, or magnetite grit would be propelled against the contaminated surface at high velocity to remove radioactivity and some of the substrate.

  - **Dry Sandblasting**: Sand propelled by compressed air could be used. However, dust is a problem with this technique. Therefore, wet blasting or vacuum blasting would be the primary blasting technique.

  - **Wet Sandblasting**: In the wet process, sand is mixed with water and propelled by air. Two disadvantages are apparent in the wet technique: (1) the wastewater as well as the sand must be retained and monitored prior to disposal; and (2) fine sand particles that are formed by destruction of the abrasive are wet and adhere to the surface being cleaned. This residue would be removed by brushing with a vacuum. Nevertheless, airborne particulates would be reduced relative to dry sandblasting.

  - **Vacuum Blasting**: A vacuum is utilized to collect sand and dust and prevent the spread of contamination.

No single technique or abrasive material would be universally applicable. The construction material, type of contamination, extent of decontamination desired, and complexity of the surface would all be considered in selecting one of the surface-abrasion techniques. The processes employing surface-abrasion techniques would be self-contained and would provide for collection of the abraded materials for off-site disposal. The cleaned metals and concrete would be left on-site when it is determined that radioactivity has been reduced to acceptable levels.

The second general treatment method, the TRU-Clean® process, addresses soil and sediment contamination. This process involves sorting excavated soil into radioactive and nonradioactive fractions using a conveyor belt equipped with FIDLER detectors, followed by gravity settling in a fluid-filled tank to further segregate and concentrate radiologically contaminated soils.

Both methods would require construction of a process building to house the treatment processes, contain the wastes, allow closer control of the radioactive materials, and protect wastes from wind and water erosion. The process building would be constructed with an area of approximately 20,000 square feet. The building would consist of a concrete slab on-grade, with steel superstructure and corrugated sheet-metal roof and walls. A blower system would be installed to maintain negative air pressure inside the structure, and air would be exhausted through HEPA filters to control potential fugitive dust emissions. Within this structure, a secure area for stockpiles would be provided. Concrete floors would be sloped to collection sumps to facilitate collection of waste liquids, and be surrounded by concrete curbs designed to eliminate run-on/run-off. A similarly-contained area would be constructed and designated for storage of concentrated waste residuals awaiting off-site shipment. A single building could be used concurrently for both general treatment methods.

Additional facilities required would include a concrete decontamination pad for heavy equipment used in excavation activities. The pad would be approximately 800 ft^2 in area, sloped to a collection sump, and surrounded by concrete curbing for containment. Decontamination water would be filtered and recycled in order to minimize generation of wastewater requiring disposal.

Asphalt, with or without paint coatings, which has been contaminated with plutonium or americium would not be treatable because it does not have the structural integrity to be sectioned and treated through surface abrasion. Moreover, it is not loose enough to use the TRU-Clean® process. Therefore, the asphalt would be removed and transported off-site for disposal.

The recommended on-site treatment activities for each of the contaminated units are summarized in the following paragraphs.

Shelter 204. It is estimated that 4,140 ft^2 of shelter floor materials and 64 ft^2 of the shelter wall material require remediation. Both concrete and steel reinforcing materials of Shelter 204 would be decontaminated. The original floor of Shelter 204 is covered by approximately six inches of concrete, poured contemporaneously with the concrete apron. Sampling results from the RI indicate that both the upper and lower surfaces of this second layer are contaminated. In addition, the upper surface of the original floor is also contaminated. Therefore, the total surface area of floor materials requiring decontamination with abrasion techniques (assuming that the two slabs of concrete can be separated) is three times the total floor area, or about 4,140 ft^2. An estimated 25 percent of the total area of the interior concrete walls require decontamination, or about 516 ft^2. An estimated 25 percent of steel structural materials would require decontamination, or 604 ft^2. Therefore, most of the shelter walls could be sectioned, scanned for radioactivity, and returned to the site with no decontamination required.

The floor and wall materials requiring decontamination would be sectioned into manageable-sized pieces no larger than a few square feet, as described above. Conventional construction saws may be adequate, though sections containing greater amounts of steel-reinforcing bars may require a special sectioning technique. Concrete sections would be decontaminated using one of the surface-abrasion methods described above. Metal components of Shelter 204 should be decontaminated using abrasive blasting, because scarification and impaction methods are ineffective on metal surfaces. Soil in the launcher pit would be removed and addressed as discussed below under contaminated soil. An estimated 10 yd^3 of radioactive wastes, including both concrete and steel, would be generated by decontamination operations conducted on Shelter 204 structural materials.

Apron and Drainage Ditch Cover. The asphalt lining in the drainage ditch would be removed prior to remediation of underlying soils. It is assumed that the entire volume of asphalt is contaminated, and would require remediation. The asphalt-lined portion of the ditch is approximately 670 feet long, with an average width of 15 feet and thickness of 2 inches. This equates to a surface area of approximately 1,120 yd^2 and an unexpanded volume of 62 yd^3. The area of asphalt to be remediated is shown in Figure 2-2.

Decontamination of the concrete-covered asphalt apron would be accomplished by sectioning the concrete into manageable-sized pieces of a few square feet each, and removing and segregating them from the layer of asphalt beneath the concrete. The underlying asphalt contains most of the associated radioactivity on its upper surface and would be containerized for off-site disposal as a LLW. The asphalt cannot be decontaminated because it is unlikely to withstand the physical decontamination techniques under consideration and remain intact. An estimated 356 yd^3 of asphalt requiring disposal as a radioactive waste would be generated from the apron. An estimated 22,500 ft^2 of concrete, 4 to 6 inches thick and contaminated on the lower surface only, would require decontamination.

After separation of concrete from asphalt, sectioned pieces of concrete would undergo decontamination. The concrete would be decontaminated using the technologies described above. The same building used to house the TRU-Clean[R] process would be used to house the decontamination process for structural materials. Decontamination of the concrete apron and soils from the asphalt-lined ditch is expected to generate an additional estimated 25 yd^3 of LLW requiring disposal. Remaining sectioned concrete would be surveyed on-site for radioactivity. Concrete found to be contaminated above threshold limits established in the RI/FS (see Table 2-1) would be either reprocessed or disposed of as LLW. Concrete found to be below limits would be left on-site.

Utility Bunkers. Utility bunkers are constructed of concrete, and are box-shaped with dimensions of 6 ft × 4 ft × 6 ft. Total interior surface area of each bunker is 331 ft^2, of which an estimated 50 percent would require decontamination. These bunkers would be excavated and removed from the ground after the concrete apron has been removed. The concrete would be sectioned and decontaminated using the same facilities and engineering controls described for the concrete apron. An estimated 2 yd^3 of LLW requiring disposal would be generated.

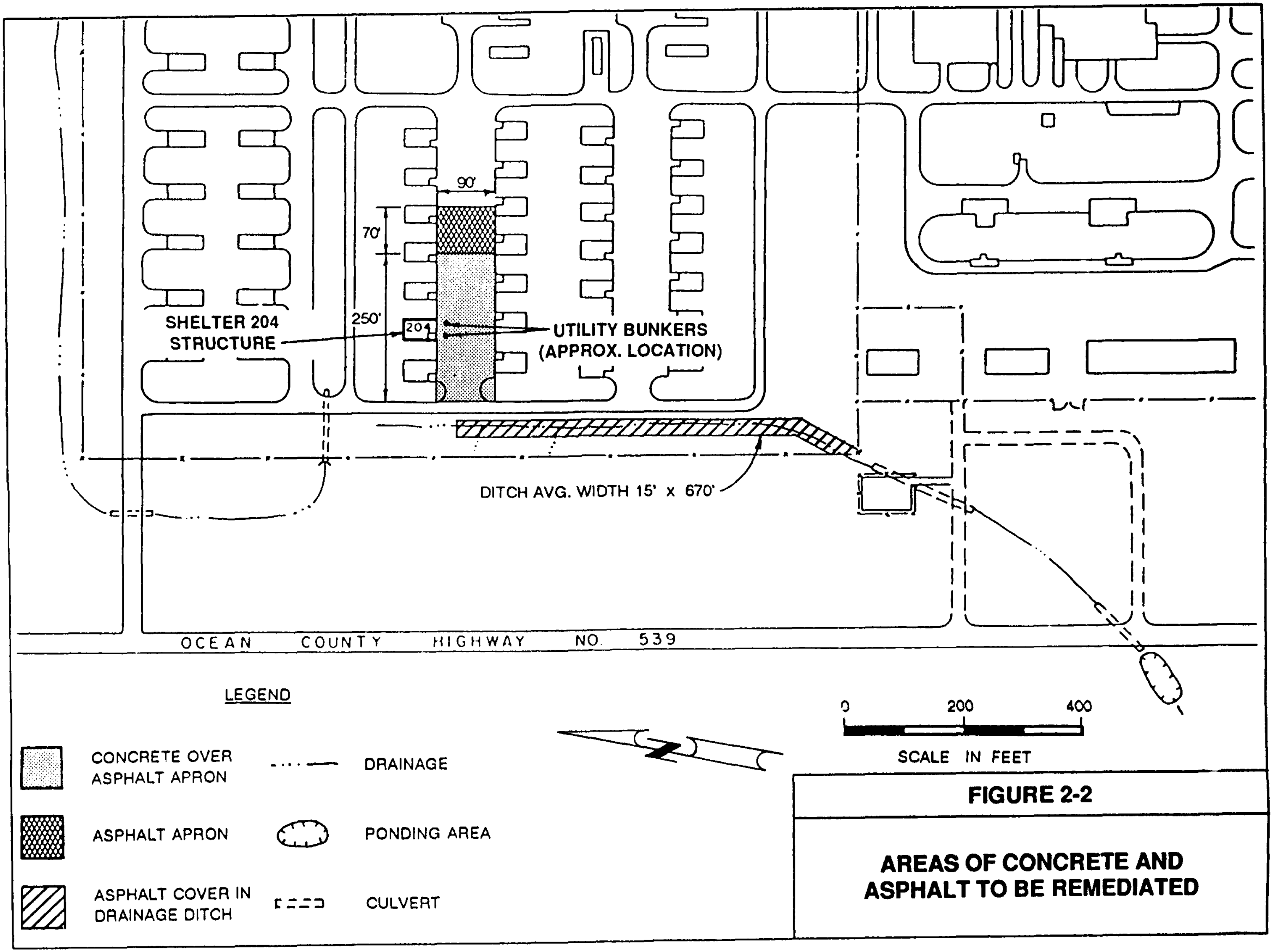

FIGURE 2-2

AREAS OF CONCRETE AND ASPHALT TO BE REMEDIATED

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Table 2-1

Threshold Limits for Decontamination of Radioactive Surfaces (Adapted from NRC Guide 1.86)

Decontamination for Release for Unrestricted Use

	Average[a] (dpm/100cm^2)	Maximum[b] (dpm/100cm^2)	Removable[c] (dpm/100cm^2)
Transuranics	100	300	20

dpm: disintegrations per minute.

Source: Termination of Operating Licenses for Nuclear Reactor. NRC Regulatory Guide 1.86.

[a]"Average" means the average dpm over a large area of the item being surveyed for release for unrestricted use.

[b]"Maximum" means the maximum dpm noted while surveying an item for release for unrestricted use.

[c]"Removable" means activity on any wipe sample taken from an item being considered for release for unrestricted use.

Contaminated Soils. Contaminated soils would be treated using the TRU-Clean[R] or similar process. This process has been tested on soils from the BOMARC Missile Site with favorable results. In order to obtain a conservative estimate of the volumes of soil to be remediated, several factors were considered. One factor considered was the potential effect of demolition of contaminated structures (concrete apron, asphalt in the drainage ditch, Shelter 204, etc.) on surrounding soils. Engineering controls designed to minimize the release of contaminants would be implemented during any demolition activities. Nevertheless, it is likely that small amounts of soil beneath and adjacent to the shelter and concrete apron would become contaminated if not already contaminated. Any soils affected would require remediation after demolition is complete. In order to estimate the volume of soils affected, "buffer zones" of soils potentially requiring remediation were established beneath and adjacent to the structures. Figure 2-1 shows areas and depths of soils to be remediated.

In establishing the "buffer zones" of soils to be remediated, the following assumptions were used:

- 100 percent of the concrete/asphalt apron would be removed. In addition, the contaminated asphalt located just east of the apron (approximately 90 × 70 feet, see Figure 2-1) would be removed. Soil from beneath the concrete and asphalt would require remediation to a depth of one foot; with a surface area of about 3,480 yd^2 this would correspond to a volume of approximately 1,400 yd^3.

- An area extending 10 to 30 feet from all sides of Shelter 204 would be affected. Soils within most of this area to a depth of 3 feet would require remediation. Soils in a small area just west of Shelter 204 would require remediation to a depth of 10 ft. This represents a surface area of approximately 775 yd^2 and a soil volume of approximately 1,215 yd^3.

In addition to soils from the "buffer zones" described above, several discontinuous areas of contaminated soils would require remediation. These areas are shown on Figure 2-1. Implementation of the On-site Treatment Alternative would, therefore, require excavation of an estimated 6,200 yd^3 of soil from the areas shown on Figure 2-1. In order to excavate contaminated soils in the asphalt drainage ditch, the asphalt cover would be removed and disposed of as LLW. The estimated unexpanded volume of asphalt that would be removed from the drainage ditch is 62 yd^3.

It is conservatively estimated that 1,860 yd^3 of concentrated wastes (contaminated soils) would be generated by the TRU-Clean[R] process. This would provide a volume reduction of approximately 70 percent. The concentrated wastes would then require disposal as LLW. Excavated areas would be restored to their original grade, covered with topsoil, and planted with species indigenous to the New Jersey Pinelands.

Environmental monitoring would be conducted during soil excavation and treatment activities. Continuous air sampling would be conducted during intrusive activities such as excavation. A network of four to six high-volume air samplers would be used to monitor for radioactive particulates. The air samplers would be used to draw large volumes of air through filters, and the filters would be analyzed daily in the field for alpha activity. If air filter analysis indicates resuspension of plutonium and/or americium, corrective measures such as spraying the soil with water would be implemented to minimize resuspension. Air sampling data collected during intrusive sampling activities of the RI suggest that resuspension of radionuclides would not pose a serious problem.

Missile Launcher. The location of the missile launcher and metal debris from Shelter 204 is currently unknown. As discussed in Section 2.3, five anomalies which could be the missile launcher were identified during a geophysical survey. Assuming that the launcher is found, additional actions would be required. All five anomalous areas may have to be excavated in the attempt to locate the missile launcher. These would be the same as those described in Section 2.3.

Disposal Contingency for Structural Materials. It is possible that some of the structural materials proposed for physical decontamination (all contaminated media except soils) would not be effectively decontaminated using available technologies. This is due to the possibility that radionuclides have migrated below the surface of the structural materials, especially concrete, thereby preventing effective decontamination by removal of surficial contamination. If this is the case, these materials would be disposed of in a permitted off-site LLW facility. Structural materials would first be separated into contaminated fractions and fractions not requiring remediation by on-site radiological surveys, followed by sectioning of contaminated portions of the materials. Fractions not requiring remediation would be left on-site. The Air Force's preferred disposal location is the Nevada Test Site.

Several mitigations would be incorporated into the remedial design developed as part of the On-site Treatment Alternative. The mitigations described for the Off-site Disposal Alternative would be implemented. All on-site treatment would be conducted in a specially constructed building protected from wind and water erosion. Concentrated wastes would be stored in a contained area prior to off-site disposal. A contained area would be constructed for storage of concentrated waste residuals prior to off-site shipment. The storage area would have concrete floors sloped to sumps to facilitate collection of leachate, and the area would be bermed to prevent runoff from entering the area and to prevent liquids from escaping the area. Air inside the building would be filtered. Additional mitigation measures that would be used include: covering exposed piles of excavated dirt, restoring disturbed excavated areas, construction of perimeter controls around the excavated areas, fencing the threatened plants at the site, construction and use of a decontamination pad, limiting truck traffic during peak community hours, and development of a H&SP specific to excavation activities.

2.6 Comparison of Alternatives

This section provides a tabular summary of the impacts and costs that would result from implementation of each of the five alternatives under consideration (Table 2-2). The impacts are assessed in Section 4.0. It should be noted that costs are based on a thirty year projection of present worth at 0.10 interest, including capital, operations, and maintenance. One time costs are assumed to be incurred in a period of one year at present worth. A thirty year projection is an accepted standard for comparison costing. Costs for NEPA No Action and Limited Action Alternatives would be higher than shown because costs would be incurred in perpetuity as activities involved in these alternatives would be required into the distant future.

2.7 Identification of the Preferred Alternative

The Air Force has identified the Off-site Disposal Alternative at a DOE radioactive waste repository as the Preferred Alternative. The Nevada Test Site repository was analyzed as a representative location.

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	Unrestricted Access		NEPA No Action
	Natural Conditions	Uncontrolled Site Development	
Geology & Soils	Low: Soil erosion rate could increase	High: Soil erosion rate could substantially increase	Negligible
Hydrology: Surface Water	Low: Flow regime altered	High: Quality, quantity, or flow regime could be adversely altered	Negligible
Hydrology: Groundwater	Low: Quantity and flow rate could be altered	High: Quality, quantity, or flow regime could be adversely altered	Negligible
Air Quality	Negligible	High: Air quality could be substantially altered with severe increases in ambient levels of pollutants	Negligible
Biology: Flora	Low: Endangered species habitat/population could be altered over time with natural succession	High: Endangered species habitat/population could be destroyed	Negligible
Biology: Fauna	Low: Habitats altered	High: Habitats could be destroyed	Negligible
Biology: Organism Contamination	Low: Potential for bioassimilation could increase	High: Potential for bioassimilation could be severely increased	Negligible
Transportation (local)	Negligible	High: Traffic volume and transportation infrastructure could be altered	Negligible
Transportation (national)	Negligible	Negligible	Negligible

	Unrestricted Access		NEPA No Action	
	Current	Future	Current	Future
Land Use	Negligible	High: Invasive activities could occur at the site.	Negligible	Moderate: Futu of the site woul foregone

	Unrestricted Access		
	Intruder-Construction	Intruder-Residence	Po
Public Health	High: Calculated dose exceeds annual background radiation dose of 180 mrem	High: Calculated dose exceeds background radiation dose of 180 mrem/yr	Negligible

	Unrestricted Access	NEPA No Action
Costs*	No Cost	$789,000

N = Negligible; L = Low; M = Moderate; H = High.

* Thirty-year present worth cost at 0.10 interest, including capital, operations and maintenance. One-time costs are ass

Table 2-2
Comparison of Alternatives

	Unrestricted Access		NEPA No Action	Limited Action		
	Natural Conditions	Uncontrolled Site Development		Short-term	Long-term	
	Low: Soil erosion rate could increase	High: Soil erosion rate could substantially increase	Negligible	Negligible	Negligible	Ne -
Water	Low: Flow regime altered	High: Quality, quantity, or flow regime could be adversely altered	Negligible	Negligible	Negligible	Ne
vater	Low: Quantity and flow rate could be altered	High: Quality, quantity, or flow regime could be adversely altered	Negligible	Negligible	Negligible	Ne
	Negligible	High: Air quality could be substantially altered with severe increases in ambient levels of pollutants	Negligible	Low: Noticeable increases in ambient level of fugitive dust and gaseous exhaust products	Negligible	Mc inc lev anc prc
	Low: Endangered species habitat/population could be altered over time with natural succession	High: Endangered species habitat/population could be destroyed	Negligible	Negligible	Negligible	Lo of old
	Low: Habitats altered	High: Habitats could be destroyed	Negligible	Negligible	Negligible	Lo dis
ontamin-	Low: Potential for bioassimilation could increase	High: Potential for bioassimilation could be severely increased	Negligible	Low: Potential for bioassimilation could increase	Negligible	Lo bio inc
)	Negligible	High: Traffic volume and transportation infrastructure could be altered	Negligible	Negligible	Negligible	Ne
nal)	Negligible	Negligible	Negligible	Negligible	Negligible	Ne

	Unrestricted Access		NEPA No Action		Limited Action	
	Current	Future	Current	Future	Current	Future
	Negligible	High: Invasive activities could occur at the site.	Negligible	Moderate: Future use of the site would be foregone	Negligible	Moderate: Future use of the site would be foregone

	Unrestricted Access			NEPA No Action	
	Intruder-Construction	Intruder-Residence	Population	Population	
	High: Calculated dose exceeds annual background radiation dose of 180 mrem	High: Calculated dose exceeds background radiation dose of 180 mrem/yr	Negligible	Negligible	N

Unrestricted Access	NEPA No Action	Limited Action	
No Cost	$789,000	Nevada Test Site Hanford Washington Site	$957,000 $1,183,000

= Low; M = Moderate; H = High.

worth cost at 0.10 interest, including capital, operations and maintenance. One-time costs are assumed to be incurred in a period of one year at present worth

Table 2-2
rison of Alternatives

Limited Action		Off-site Disposal		On-site Treatment	
ɪrt-term	Long-term	Short-term	Long-term	Short-term	Long-term
e	Negligible	Negligible	Negligible	Negligible	Negligible
e	Negligible	Negligible	Negligible	Negligible	Negligible
e	Negligible	Negligible	Negligible	Negligible	Negligible
ticeable in ambient ugitive dust ous exhaust	Negligible	Moderate: Adverse increases in ambient levels of fugitive dust and gaseous exhaust products	Negligible	Moderate: Adverse increases in ambient levels of fugitive dust and gaseous exhaust products	Negligible
e	Negligible	Low: Localized loss of oak-pine forest and old field habitats	Moderate: Localized faunal displacement and loss of threatened plants as habitat changes	Low: Localized loss of oak-pine forest and old field habitats	Moderate: Localized loss of threatened plants as habitat changes
e	Negligible	Low: Localized faunal displacement	Low: Localized faunal displacement	Low: Localized faunal displacement	Low: Localized faunal displacement
ential for lation could	Negligible	Low: Potential for bioassimilation could increase	Negligible	Low: Potential for bioassimilation could increase	Negligible
e	Negligible	Negligible	Negligible	Negligible	Negligible
e	Negligible	Negligible	Negligible	Negligible	Negligible

Limited Action		Off-site Disposal		On-site Treatment	
Current	Future	Current	Future	Current	Future
gligible	Moderate: Future use of the site would be foregone	Negligible	Negligible	Negligible	Negligible

	NEPA No Action	Limited Action	Off-site Disposal	On-site Treatment
	Population	Population	Population	Population
	Negligible	Negligible	Negligible	Negligible

Limited Action		Off-site Disposal		On-site Treatment	
a Test Site	$957,000	Nevada Test Site	$6,800,000	Nevada Test Site	$8,464,000
rd Washington Site	$1,183,000	Hanford Washington Site	$23,105,000	Hanford Washington Site	$13,533,000

curred in a period of one year at present worth. Details of the cost estimates are found in the RI/FS, Section 5.3.

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SECTION 3.0

AFFECTED ENVIRONMENT

3.0 AFFECTED ENVIRONMENT

This section describes the existing environmental baseline conditions which would be affected by the alternatives. The section is divided into major subsections. The first section describes the contaminated environment at the site. The remaining subsections provide descriptions of the environmental condition of physical and human resources. This includes descriptions for the geology and soils, hydrology, air quality, biology, land use, and transportation. In addition, a radiological characterization of the site is included.

3.1 Volumes and Types of Contaminated Materials

The primary contaminants of concern, ^{239}Pu and americium-241 (^{241}Am), have been detected in site soils, sediments, structural materials, and beneath the concrete/asphalt apron. The location and activity ranges are presented in Figure 3-1.

The determination of the extent of contamination is a function of the cleanup level established by the Air Force in consultation with the regulators. The risk based cleanup level for soils developed in the RI/FS is based directly on the output from a computer code used by DOE for calculating site-specific guidelines for allowable residual concentrations of radionuclides in soil. An effective dose equivalent of four millirem per year was used as the dose limit for derivation of the cleanup level. This dose represents a lifetime cancer risk of less than 10^{-4} (Burley, 1990). The code output indicates that 8 pCi/g represents a cleanup level that would eliminate any unacceptable lifetime cancer risk from contaminated soil at the BOMARC Missile Site.

Table 3-1 summarizes the estimated surface areas and volumes of contaminated media at the site.

<u>Contaminated Soil</u>: The RI indicated that radionuclide contamination in soils is concentrated mainly in the top few inches, and in discrete "hot spots." This field observation correlates well with known, limited aqueous solubilities of plutonium and americium isotopes. Radionuclides do not appear to have migrated more than a few inches vertically since the 1960 accident. The current areal extent of contamination (see Figure 3-1) appears to be largely the result of fallout from the accident, mechanical tracking, and fire fighting activities.

The depth of plutonium contamination greater than 8 pCi/g was generally found to be less than one foot across the site. Soil borehole sampling data presented in Section 4.1.3.8.1 of the RI/FS indicate that plutonium activity for samples taken below a depth of two feet was less than 8 pCi/g in all but two boreholes. The highest activity below two feet is 39 pCi/g, which is above the risk-based level. Soil sampling data presented in Section 4.1.3.8.3 of the RI/FS indicate that plutonium contamination in excess of 200 pCi/g extends to a depth of at least 18 inches in a small area of the asphalt-covered drainage ditch, just west of the concrete apron. Samples below 18 inches were not obtained at this location, therefore the vertical extent of contamination is undetermined. The total volume of soil that would be impacted by the Preferred Alternative or the On-site Treatment Alternative is estimated at 6,200 yd^3 in the RI/FS.

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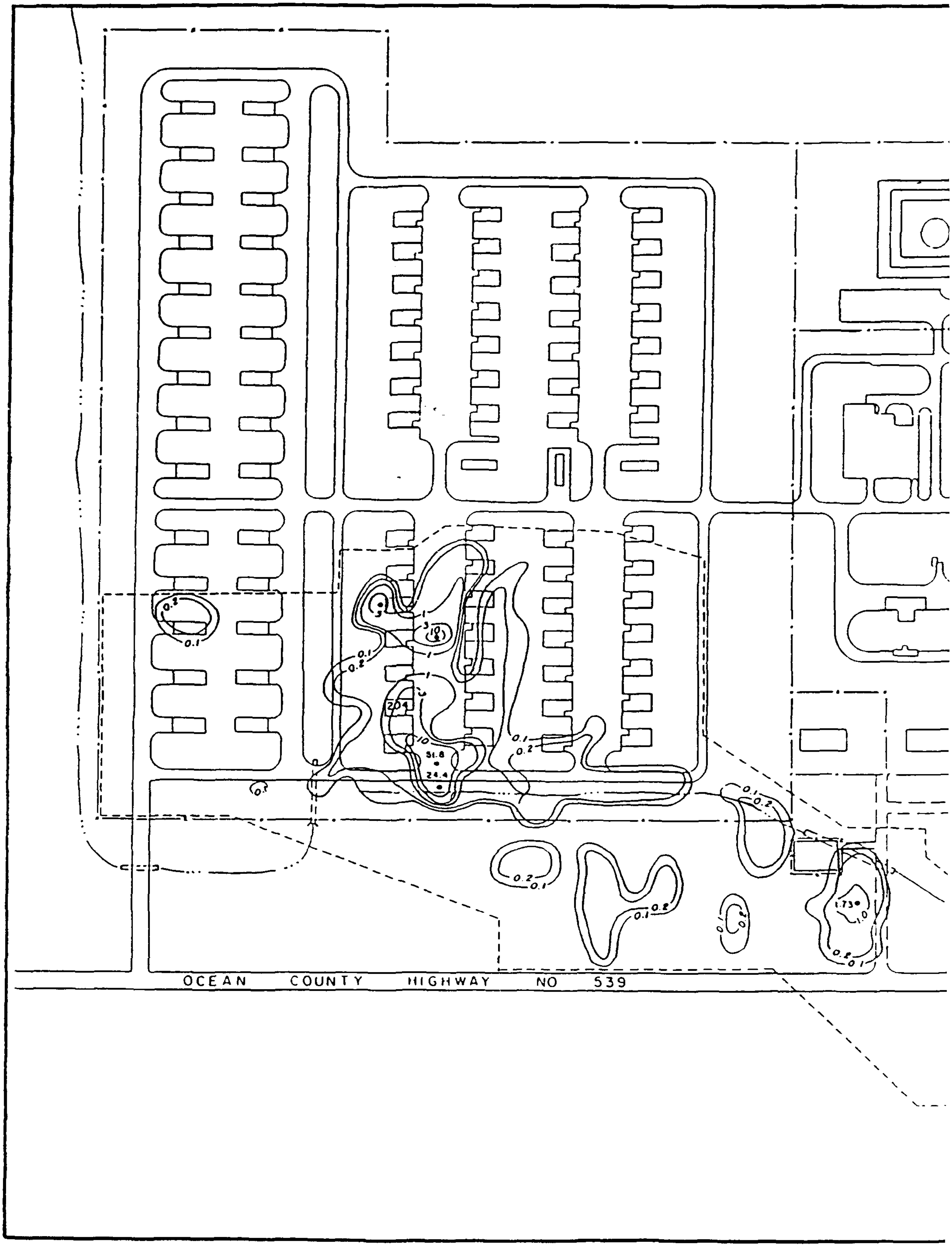
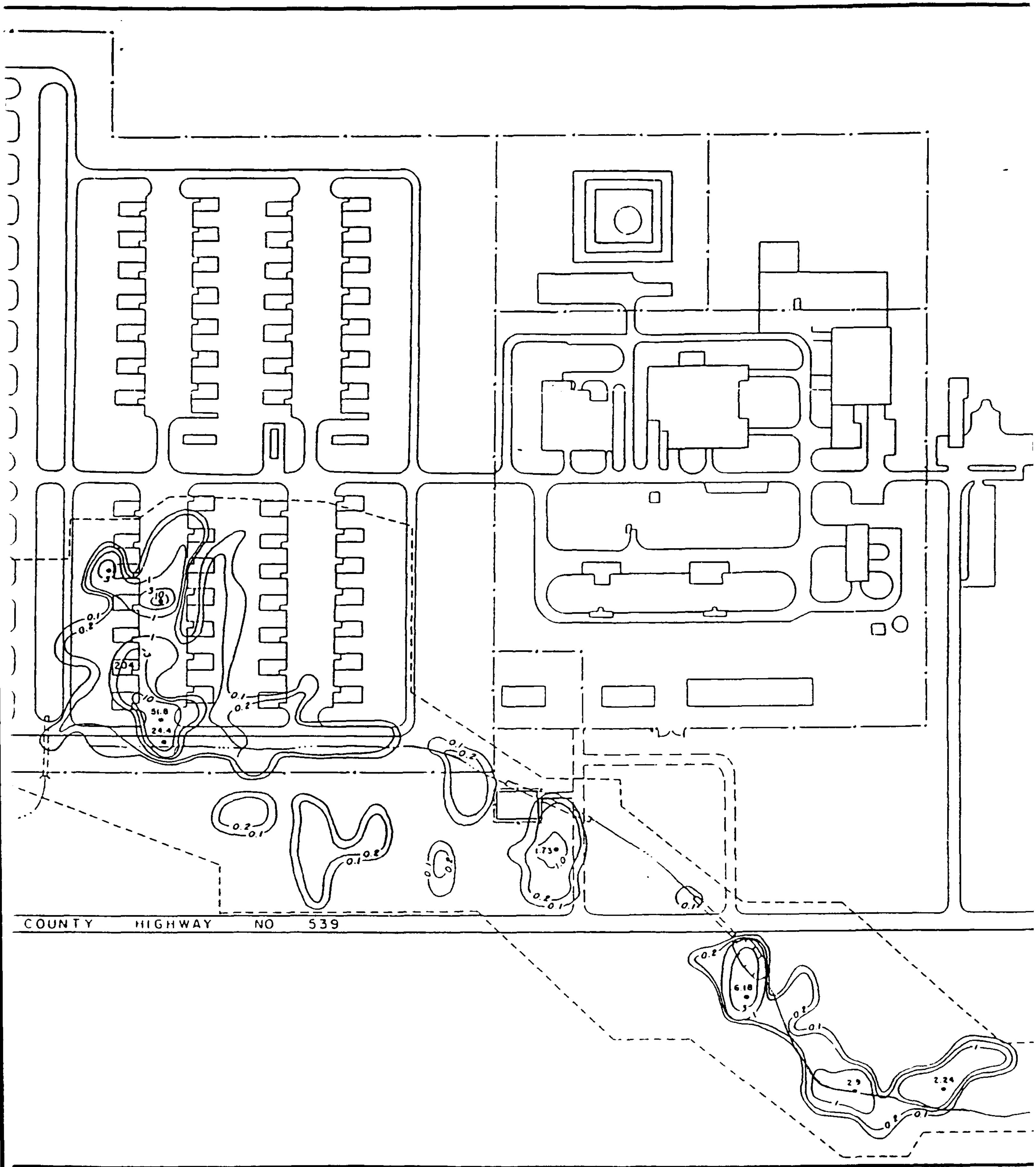

OCEAN COUNTY HIGHWAY NO 539
0.1
0.2
1
3
10
20.4
51.8
24.4
1.73
1.0


COUNTY HIGHWAY NO 539
51.8
24.4
204
10
3
1
0.1
0.2
1.73
1.0
6.18
2.9
2.24

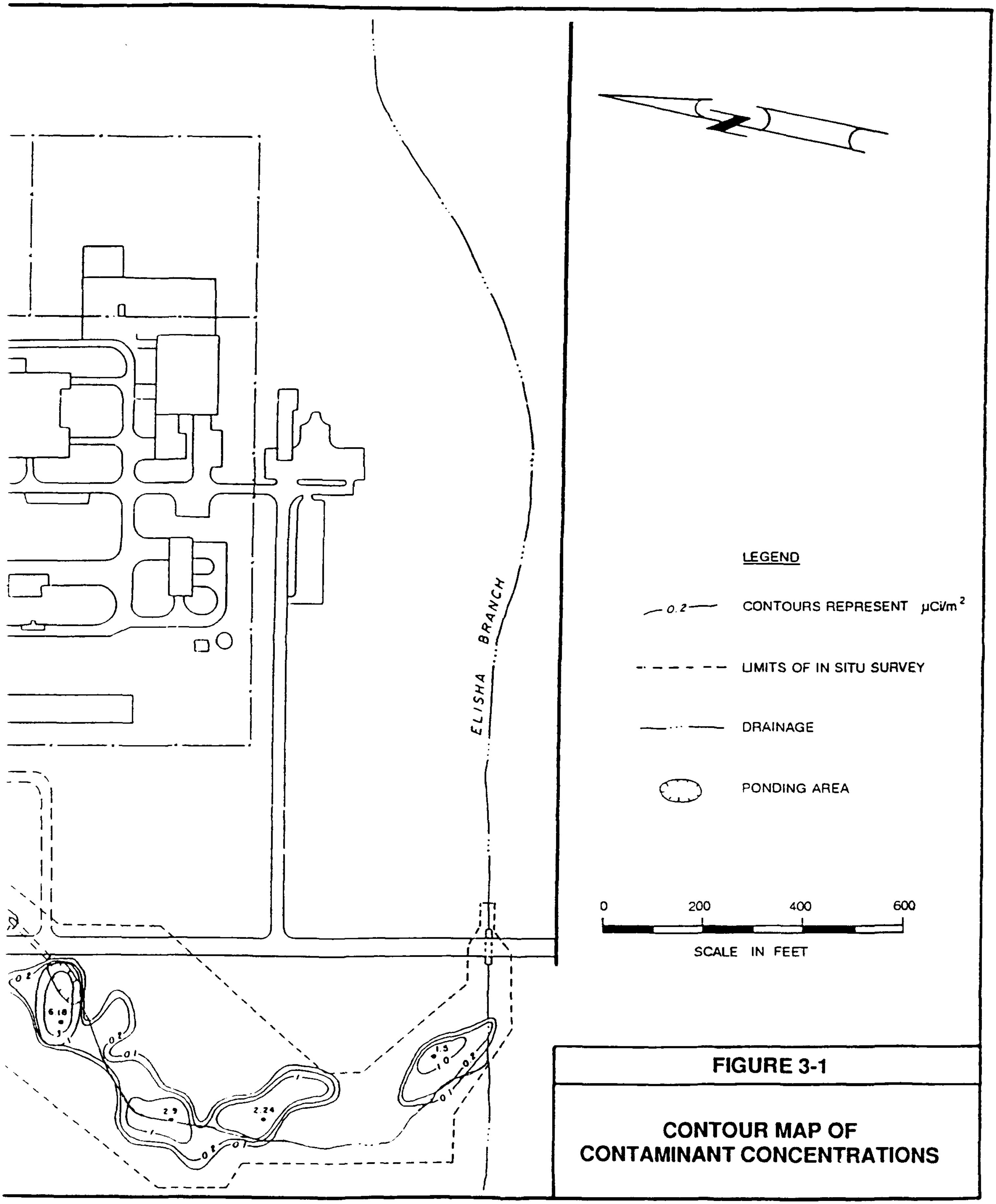


FIGURE 3-1

CONTOUR MAP OF CONTAMINANT CONCENTRATIONS

3-3

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Table 3-1
Areas and Volumes of Contaminated Media

Contaminated Media	Area (yd^2)	In-place[a] Volume (yd^3)	Expanded[b] Volume (yd^3)
Soils and Sediment	11,650	5,150	6,200
Concrete Apron	2,500	291	582
Asphalt Apron	3,200	178	356
Asphalt Cover in Drainage Ditch	1,120	62	124
Shelter 204	584	201	402
Utility Bunkers	38	18.5	37
Missile Launcher[c]	14	5	N/A
	19,136	5,905	7,707

N/A Not Applicable

[a] Excavated volumes. Includes expansion factor of 0.20 for soils, 2.0 for asphalt and concrete.
[b] In-place volumes. Does not include volume increase from excavation.
[c] Values are estimates from general knowledge of BOMARC Missile Launchers, specific locations and dimensions are not known for BOMARC Missile Site.

Apron/Drainage Ditch: Based on field measurements conducted during the RI, the total contaminated area of the concrete apron in front of Shelter 204 is approximately 2,500 yd^2. Core samples contained levels of plutonium as high as 1,070 μCi per sample at the point of the contact between concrete and underlying asphalt. Sampling data from the RI indicate that approximately 3,200 yd^2 of the asphalt apron is contaminated. It is estimated that the concrete apron will yield an expanded volume of 582 yd^3 of material, and the asphalt apron will yield an expanded volume of 356 yd^3.

The asphalt cover in the drainage ditch was assumed to be contaminated. The asphalt-covered portion of the ditch is approximately 670 feet long, with an average width of 15 feet and thickness of 2 inches. The asphalt's area is approximately 1,120 yd^2 and has an expanded volume of 124 yd^3.

Shelter 204: The shelter is one of a series of above-ground buildings, separated from one another by approximately 30 feet. The building has been unused and is exposed to the elements since the incident. Alpha surveys conducted at over 600 points on the Shelter 204 walls and the floor using a PAC-4G instrument, showed that high activity levels detected in Shelter 204 were 2,011 dpm per 100 cm^2, 47,780 dpm per 100 cm^2, and 2,106 dpm per 100 cm^2. Concrete cores taken through the shelter floor showed levels of plutonium as high as 65 μCi per sample on the original floor. The RI/FS estimated that sectioning and excavation of the shelter would generate an expanded volume of 402 yd^3 of material. The metal doors on the shelter were removed and their location has not been determined. A geophysical survey of areas that may have been used for disposal of the missile launcher and other metal debris is summarized below.

Utility Bunkers: Underground utility bunkers supporting the missile shelter consist of two steel reinforced concrete compartments, each having dimensions of 6 ft × 4 ft × 6 ft deep. Alpha surveys taken in the bunkers during the RI showed activity ranging up to 80,000 direct alpha cpm (or 226,629 dpm). Sediments were encountered and sampled in one bunker; analytical results showed activity of 200 pCi/g. Sectioning and removal of the bunkers would generate approximately 37 yd^3 of expanded material.

Missile Launcher: The missile launcher from Shelter 204 was removed from the shelter shortly after the accident. Presumably, the launcher was buried or otherwise disposed of on-site or near the site. A review of records and of aerial photos, and interviews have failed to indicate the manner or location of burial. A geophysical investigation was conducted, focusing on areas thought to be likely disposal sites. Two geophysical techniques, magnetic profiling and ground-penetrating radar profiling, were used in an attempt to identify possible burial locations on-site and near the site. (See Section 3.4.1 of the RI report for details.) For any given site a number of anomalies were detected. Each anomaly was assigned an arbitrary number. As a result of evaluation of the surveys, a total of five anomalous areas were identified that could represent the buried launcher (see Figure 3-2 for locations). The volume of the missile launcher was estimated at 5 yd^3 in the RI/FS.

3.2 Geology and Soils

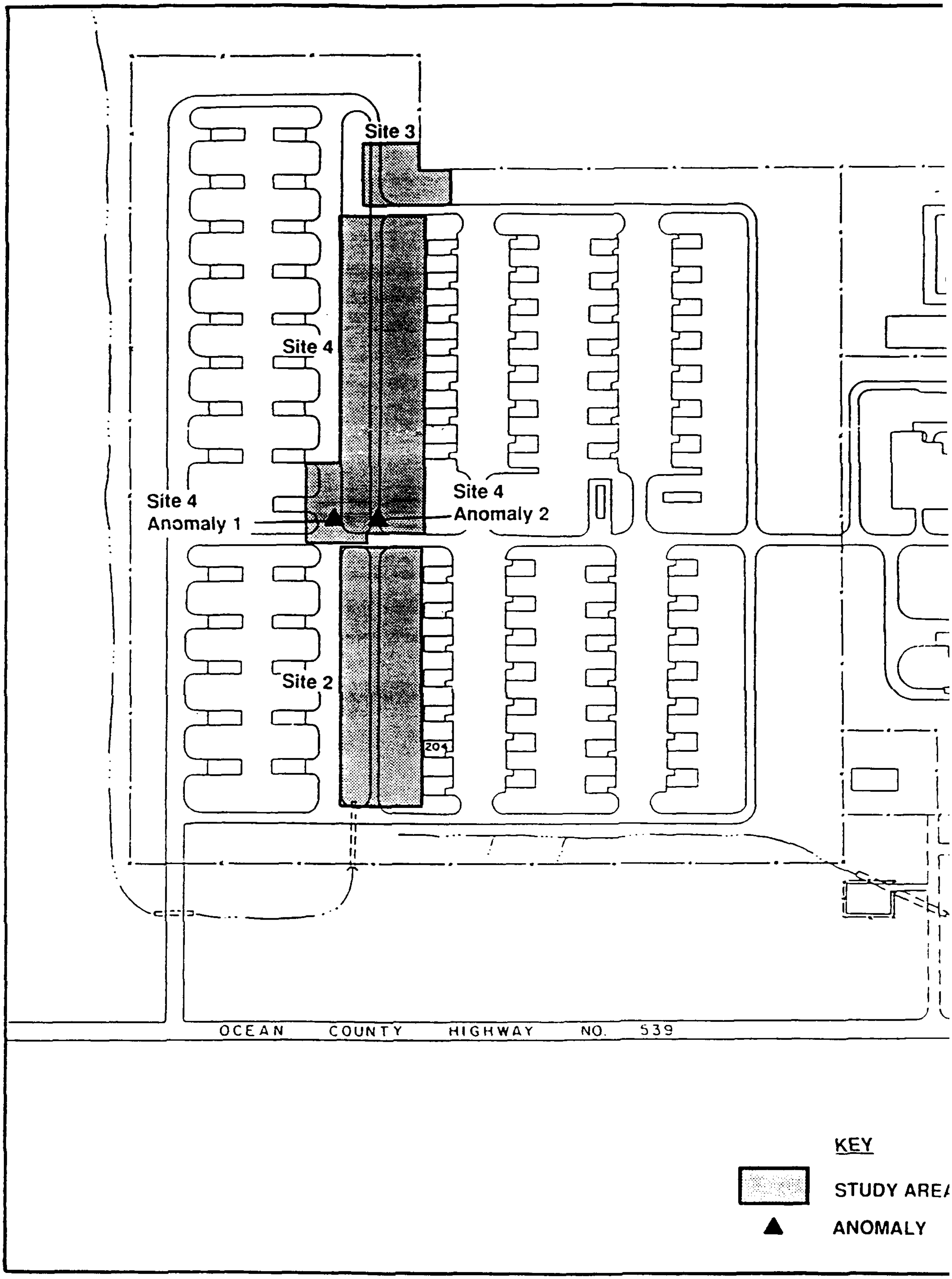
The geology and soils at the BOMARC Missile Site are described in this section. The geology and soils Region of Influence (ROI) is defined. The site and regional topography, stratigraphy, and geological structure are described. The engineering characteristics of the formations are summarized and the geologic hazards and resources are assessed. The surface geology, including descriptions of unconsolidated rocks and soil, is characterized.

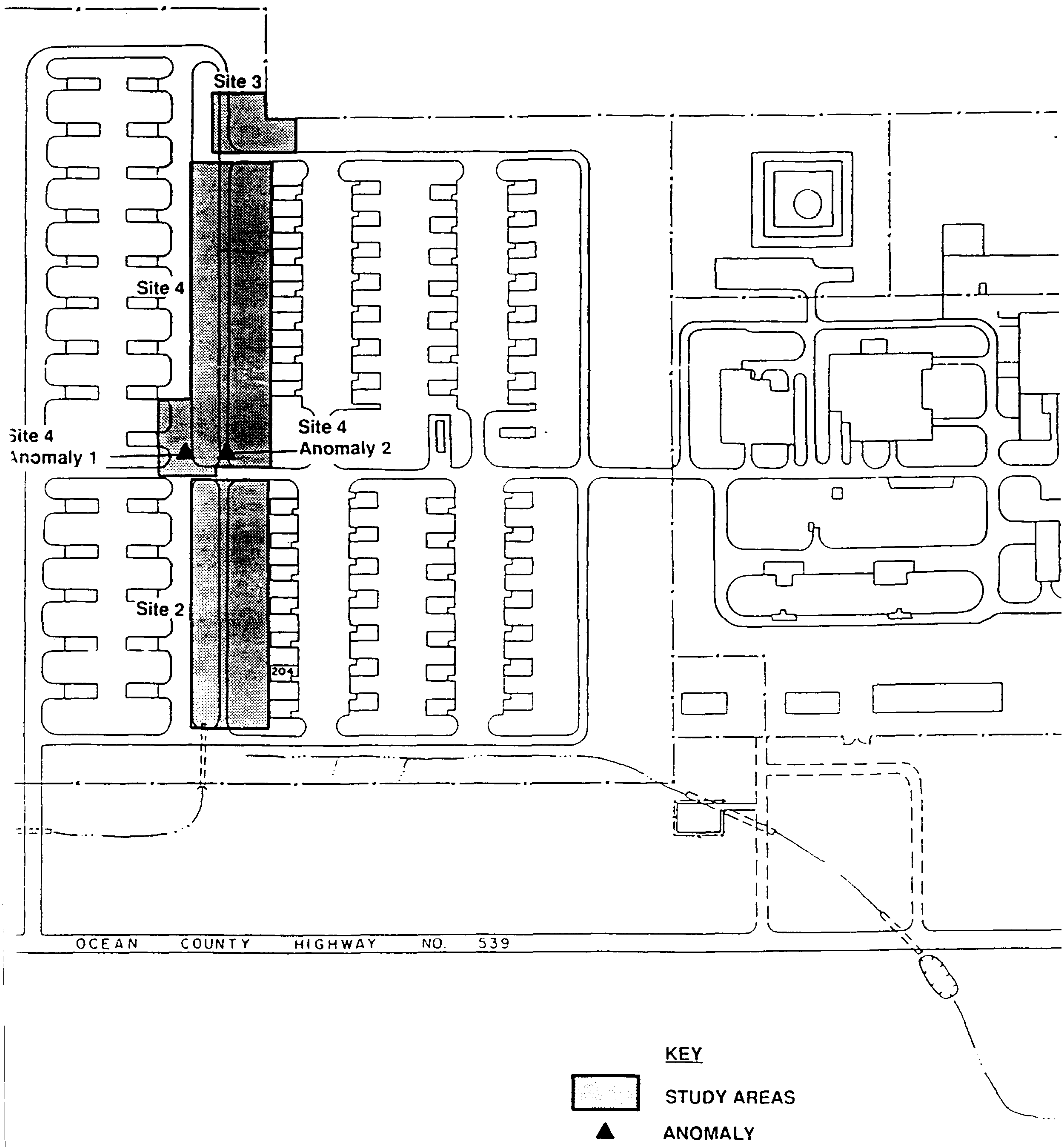
3.2.1 Region of Influence

The ROI includes portions of the local geological setting (shallow soils of the Cohansey formation) which could have been effected by the BOMARC plutonium release (see Figure 3-3). The ROI includes areas between and immediately surrounding previous sample stations which yielded analytical results equal to or above 8 pCi/g (the calculated cleanup criterion for ^{239}Pu as determined in the RI/FS).

3.2.2 Topography

The BOMARC Missile Site is located on the Atlantic Coastal Plain of New Jersey. The coastal plain topography is gently rolling with minimal change in relief. Elevations range from approximately 200 feet above mean sea level (MSL) to approximately 60 feet above MSL. The coastal plain is divided into two main drainage areas. The inner coastal plain drains into the Delaware River Basin (see Figure 3-4), and the outer coastal plain drains directly into the Atlantic Ocean. The BOMARC Missile Site lies in the outer coastal plain along its northern border, and is just east of the drainage divide separating the outer and inner coastal plains (Battelle Columbus Division, 1988).


Site 3
Site 4
Site 4
Anomaly 1
Site 4
Anomaly 2
Site 2
204
OCEAN COUNTY HIGHWAY NO. 539
KEY
STUDY AREA
ANOMALY



Site 3
Site 4
Site 4
Anomaly 1
Site 4
Anomaly 2
Site 2
204
OCEAN COUNTY HIGHWAY NO. 539
KEY
STUDY AREAS
ANOMALY

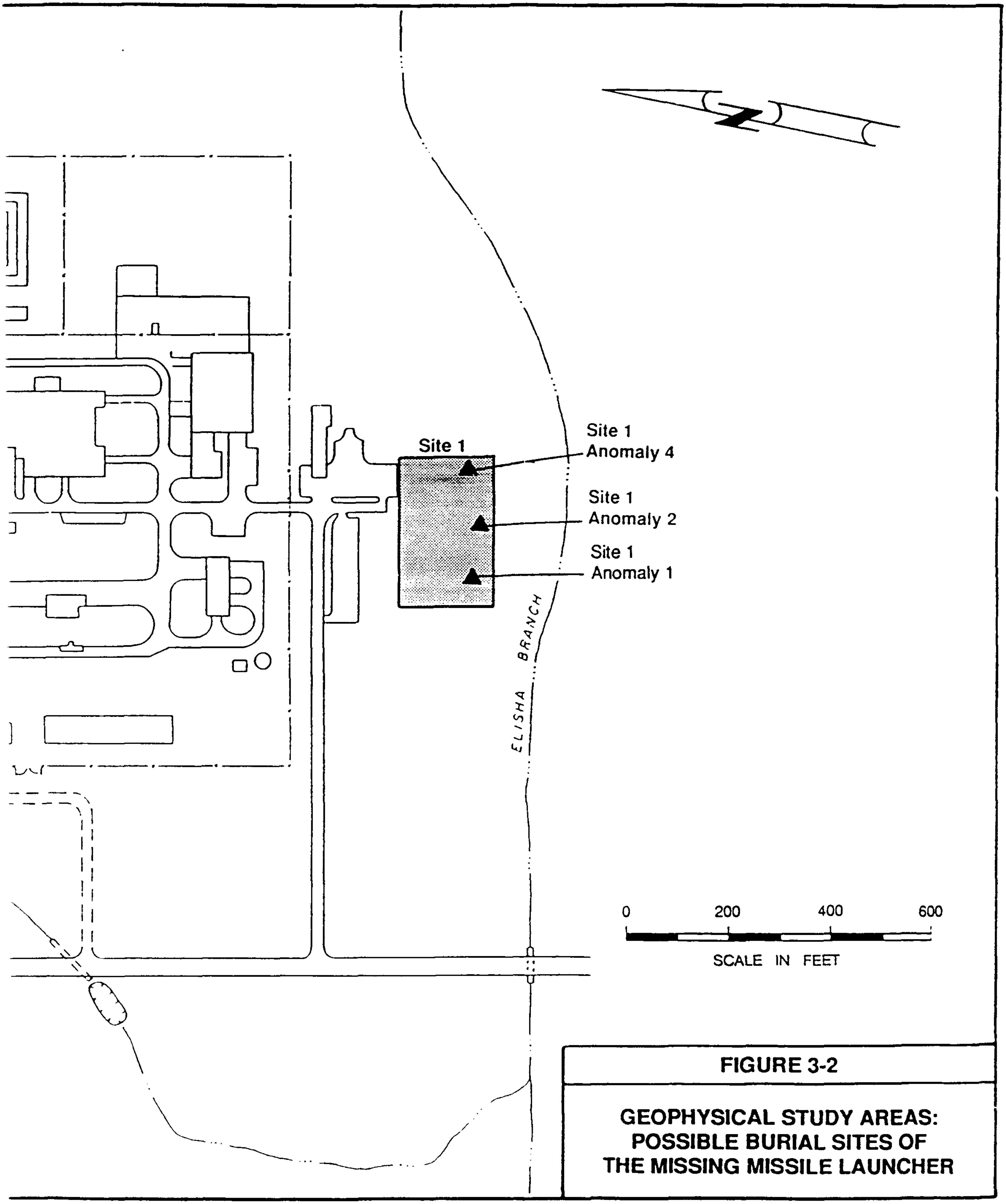


FIGURE 3-2

GEOPHYSICAL STUDY AREAS: POSSIBLE BURIAL SITES OF THE MISSING MISSILE LAUNCHER

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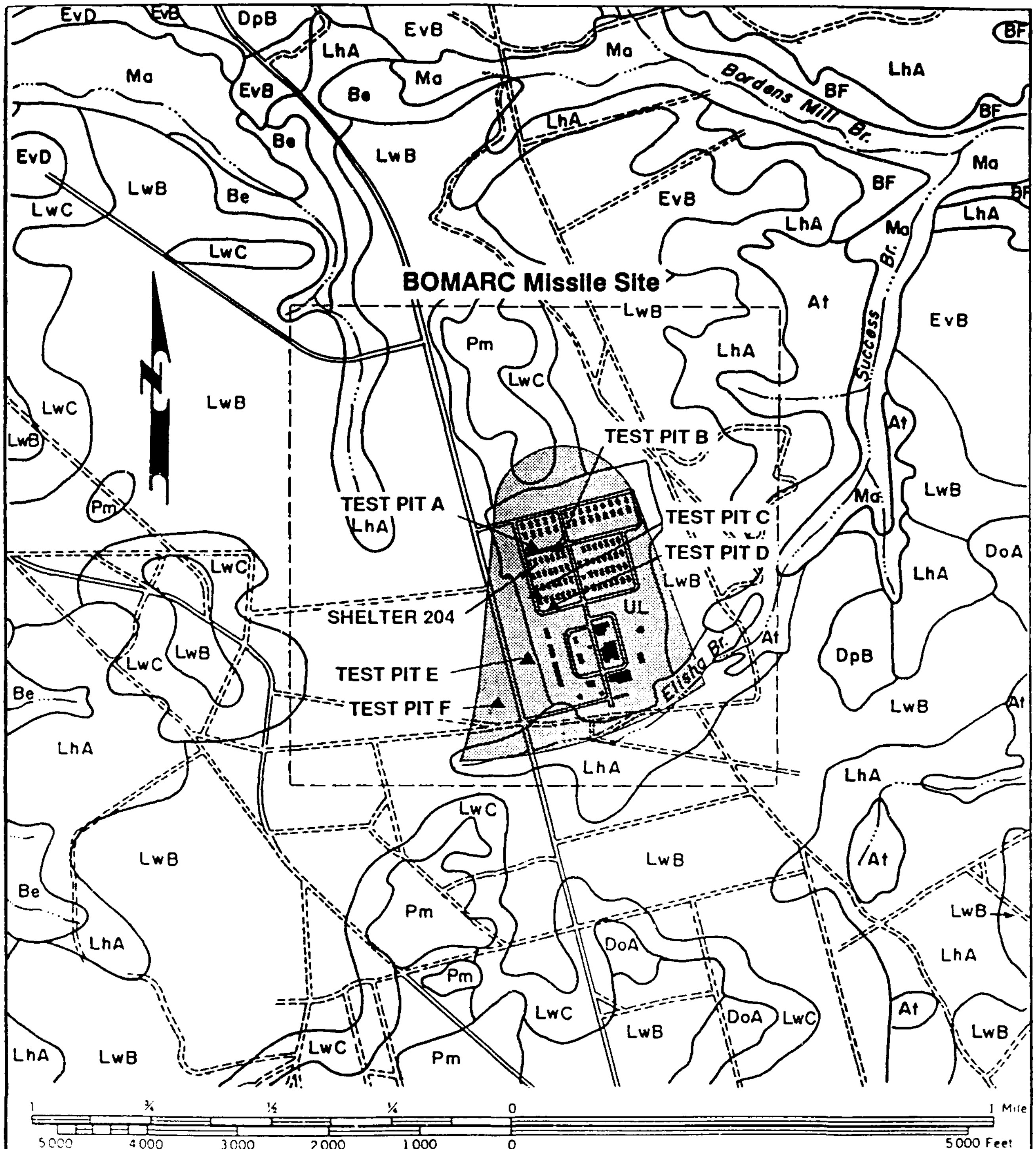

Scale 1:20000

▲ LOCATION OF TEST PITS

Soil Region of Influence

Source: Hole and Smith, 1980.

SOILS

At - Atsion sand
Be - Berryland sand
BF - Berryland sand, frequently flooded
DoA - Downer loamy sand, 0% - 5% slopes
DpB - Downer sandy loam, 2% - 5% slopes
EvB - Evesboro sand, 0% - 5% slopes
EvD - Evesboro sand, 10% - 15% slopes
LhA - Lakehurst sand, 0% - 3% slopes
LwB - Lakewood sand, 0% - 5% slopes
LwC - Lakewood sand, 5% - 10% slopes
Ma - Manahawkin muck
Pm - Pits, sand & gravel
UL - Urban Land

FIGURE 3-3

SITE SOIL REGION OF INFLUENCE, SOIL TYPE, AND TEST PIT LOCATION MAP AT THE BOMARC MISSILE SITE

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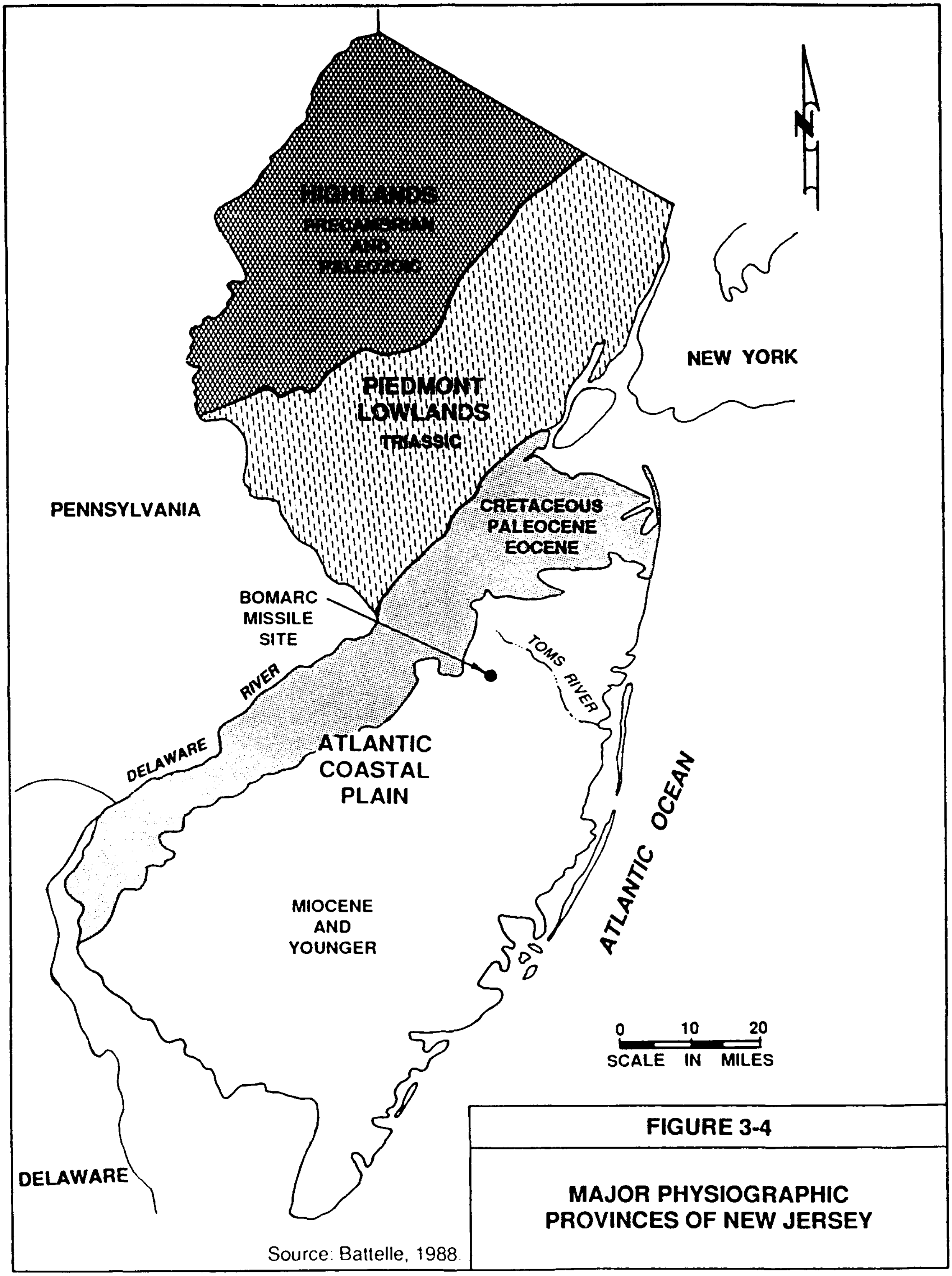

Source: Battelle, 1988

FIGURE 3-4

MAJOR PHYSIOGRAPHIC PROVINCES OF NEW JERSEY

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Due to the area's low relief, surface drainage around the site is generally very slow, and much of the surrounding lowland is a swamp. The Elisha Branch of Tom's River lies to the south and east of the facility, and provides the area's only natural surface drainage (see Figure 3-5) (Battelle Columbus Division, 1988; U.S. Geological Survey, 1977).

The missile shelters at the BOMARC Missile Site are perched atop a small rise (see Figure 3-5). The maximum elevation at the site is 182 feet above MSL, just to the east of the West Missile Shelter Area. The lowest elevation at the site, near the southeast border of the facility, is approximately 130 feet above MSL. The West Missile Shelter Area, which includes Shelter 204), slopes very slightly to the west. The area around the shelter dips gently, less than a 1.25% grade, to the southwest. A small drainage ditch lies just west of the shelter. This ditch runs nearly due south for about 1,200 feet before it crosses underneath Ocean County Route 539 by way of a drainage culvert, and connects to a depression or ponding area west of the highway. Two inches of asphalt were placed along the bottom of the ditch in June 1960 after the fire at Shelter 204, in an effort to control the spread of plutonium contamination (Battelle Columbus Division, 1988). A small draw connects the ponding area with Elisha Branch to the south.

3.2.3 Stratigraphy

The BOMARC Missile Site is situated on the Atlantic Coastal Plain Province of New Jersey. It rests on top of a thick wedge of poorly consolidated marine and continental sediments of Cretaceous and Tertiary age. The uppermost unit at the BOMARC Missile Site consists of about 40 feet of the Cohansey Sand Formation. Volume 3, Appendix 3-1 contains more detailed descriptions of formations known to underlie the Atlantic Coastal Plain together with illustrations, e.g., regional cross-section, geologic chronology.

The BOMARC Missile Site rests atop a thick wedge of unconsolidated Tertiary- and Cretaceous-age sediments, which comprise the New Jersey coastal plain formations. These sediments lie unconformably on top of an inclined erosional surface of the basement complex, which is composed of a sequence of metamorphic gneisses and schists of Precambrian, Cambrian, possibly Ordovician, and Triassic age. This basement complex contains the remains of the eastern flank of the Appalachian Mountains. The Appalachians were uplifted in the early Paleozoic and subsequently eroded during the Triassic, filling the basins which flanked the mountains. Continued erosion and deposition produced the Cretaceous and Tertiary deposits of the Atlantic Coastal Plains Province (Battelle Columbus Division, 1988).

The sedimentary sequence underneath the BOMARC Missile Site contains both marine and continental sedimentary units, and includes units of clay, sand, and gravel (Figure 3-6). All of the formations dip slightly toward the southeast. The wedge thickens considerably in the down-dip, or southeasterly direction. In Ocean County, the sedimentary wedge ranges in thickness from about 1,000 feet in the northern part of the county to approximately 4,000 feet in the southern portion of the county (Lyttle and Epstein, 1987).

The sedimentary sequence of the New Jersey coastal plain is marked by a number of unconformities, which record periods of uplift (or regression) and subsequent erosion. In addition to the unconformity on top of the basement complex, there is a major unconformity separating the base of the lowest Tertiary formation from the top of the uppermost Cretaceous

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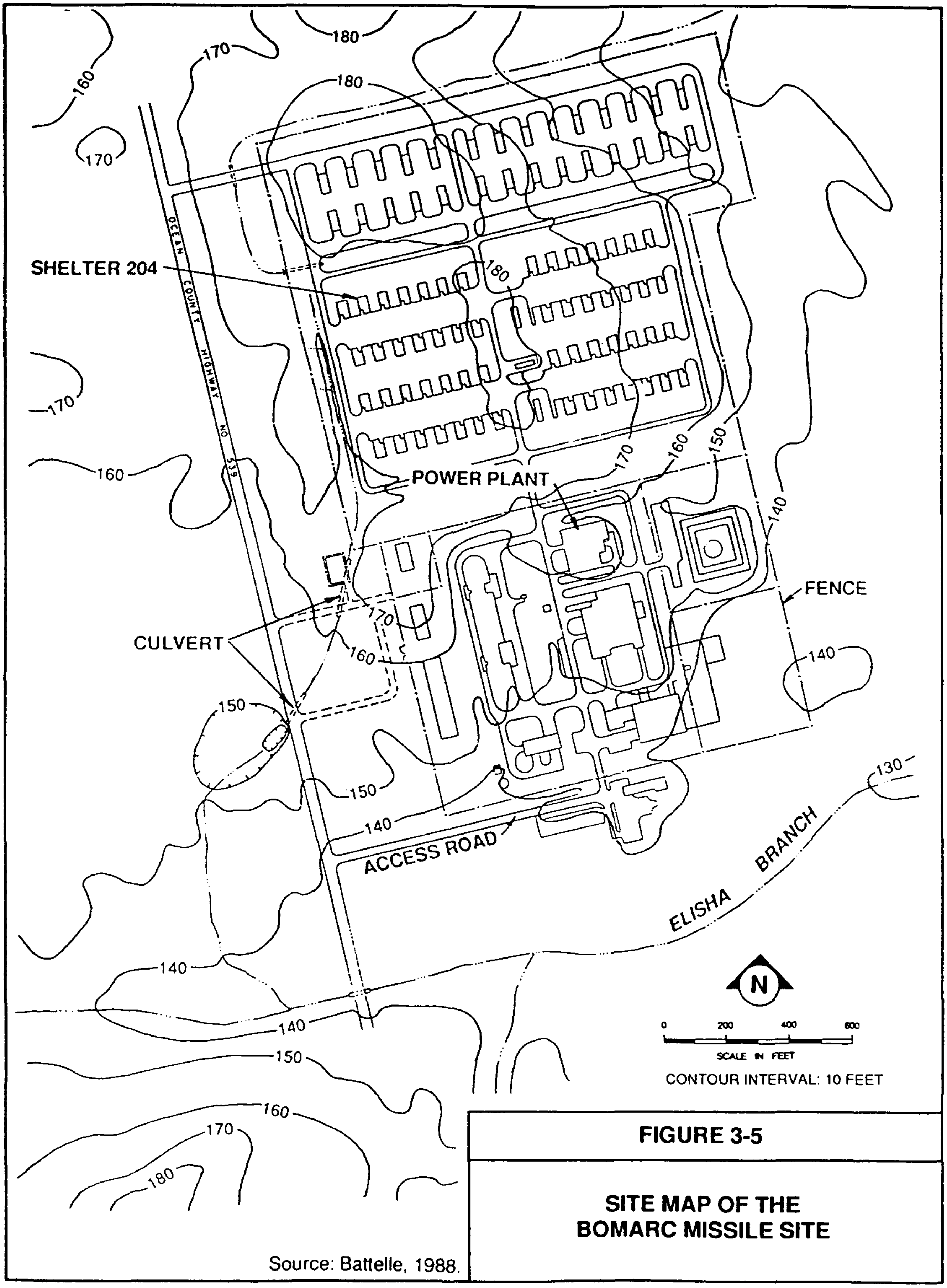

FIGURE 3-5

SITE MAP OF THE BOMARC MISSILE SITE

Source: Battelle, 1988.

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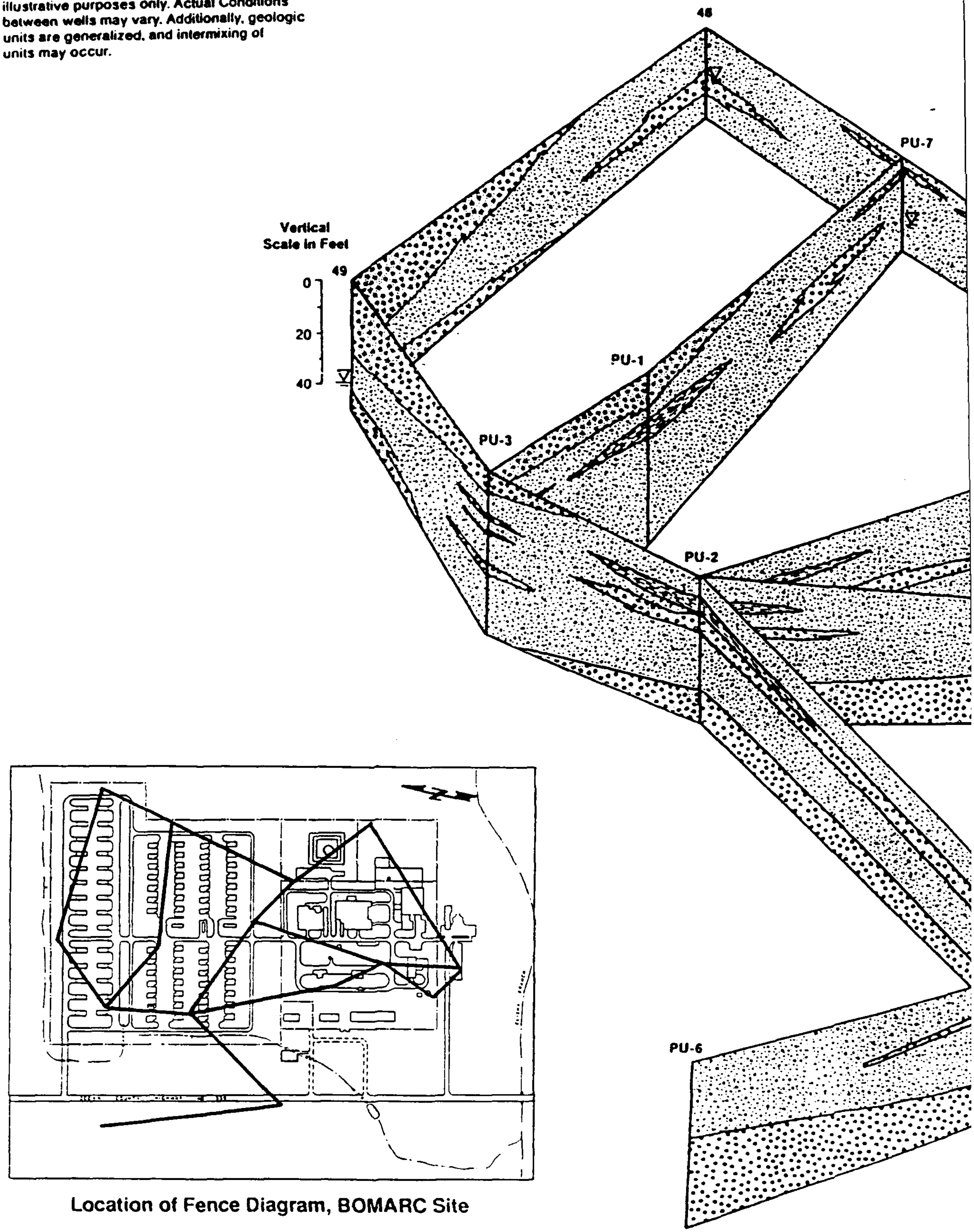
Note:
Correlation lines are drawn for illustrative purposes only. Actual Conditions between wells may vary. Additionally, geologic units are generalized, and intermixing of units may occur.



Location of Fence Diagram, BOMARC Site

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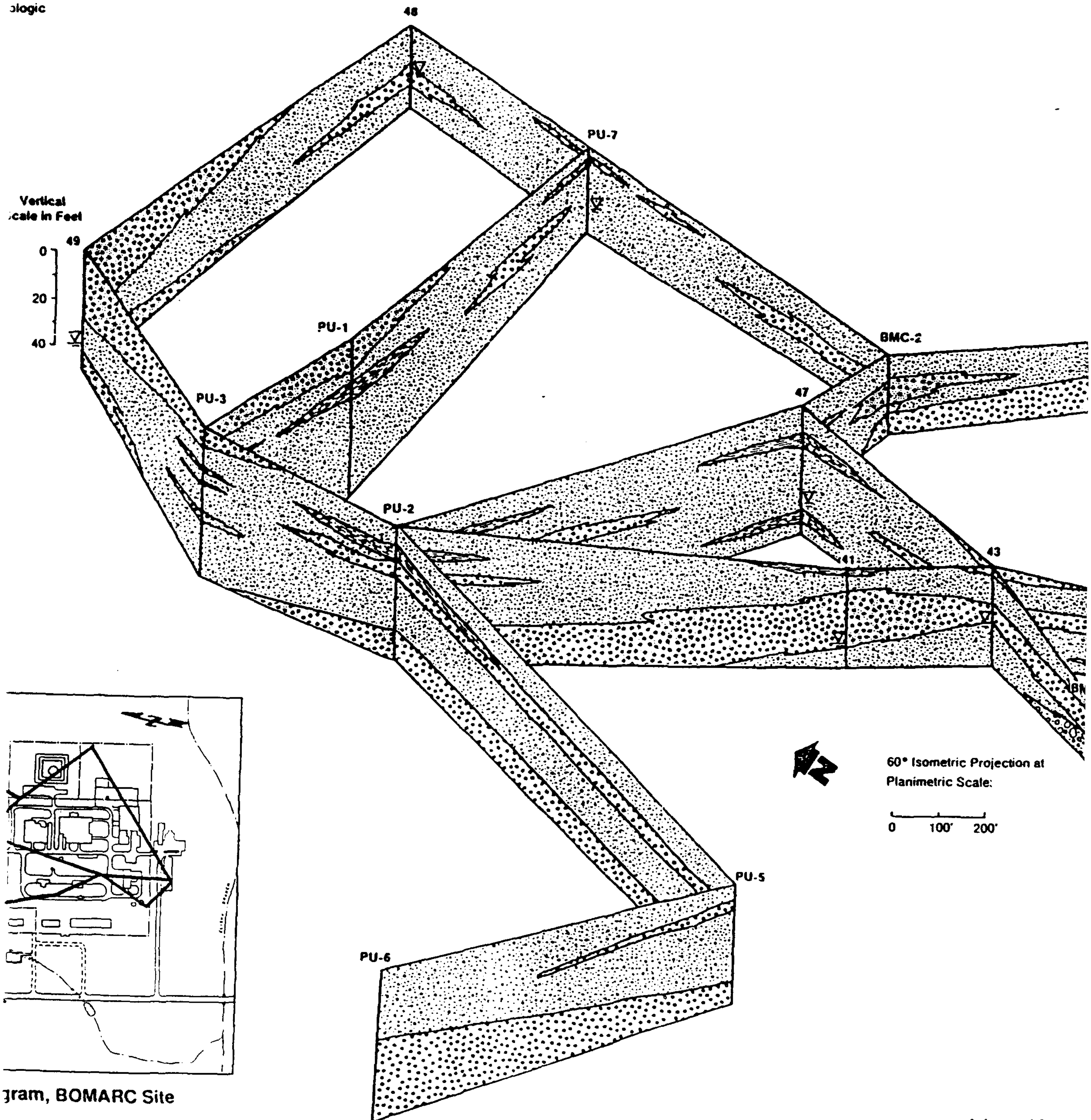
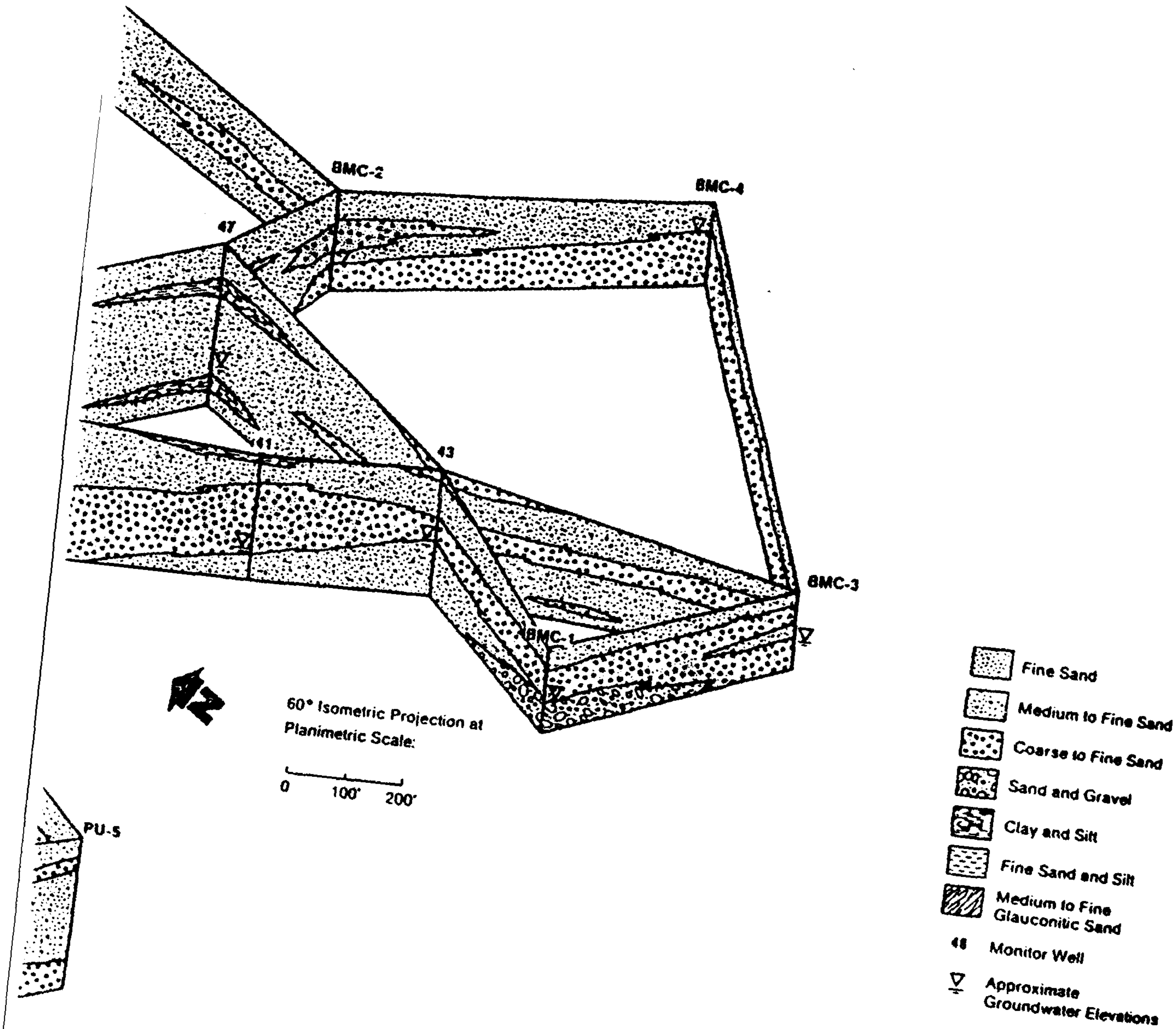


gram, BOMARC Site

Adapted from:



Adapted from: Weston, 1988.

FIGURE 3-6

FENCE DIAGRAM
BOMARC MISSILE SITE

3-3

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formation. Many of the formations within the Tertiary sequence also contain basal unconformities which separate one formation from another. Some of the Cretaceous formations may also contain basal unconformities or disconformities (Minard and Owens, 1962).

3.2.4 Geologic Structure

The strikes and dips of the different formations change systematically with decreasing age. Most of the Cretaceous formations have essentially identical strikes and dips, with only small local variations. The Cretaceous formations have a strike of approximately N47E, with a dip of about 35 feet per mile to the southeast. The Tertiary formations, however, strike in a progressively more easterly direction upsection, and the dips gradually become shallower. The basal Tertiary formation, the Hornerstown Formation, has a local strike of N53E and a dip to the southeast of 45 feet per mile. The Cohansey Sand Formation is the uppermost formation in the vicinity of the BOMARC Missile Site. Its strike is N72E, and it dips only 10 feet per mile to the southeast (see Table 3-2).

Table 3-2
Attitudes[a] of Selected New Jersey Geologic Formations

Age	Formation	Average Strike (Degrees)	Average Dip (feet/mile)
Tertiary	Cohansey Sand	N72E	SE 10
Tertiary	Kirkwood	N70E	SE 18
Tertiary	Manasquan	N62E	SE 25
Tertiary	Vincentown	N56E	SE 30
Tertiary	Hornerstown Sand	N53E	SE 45
Cretaceous	Red Bank Sand	N47E	SE 35
Cretaceous	Navisink	N47E	SE 35
Cretaceous	Mount Laurel Sand	N47E	SE 35
Cretaceous	Wenonah	N46E	SE 35
Cretaceous	Marshalltown	N46E	SE 35

Source: Battelle Columbus Division, 1988.
[a] Calculated on the basal beds of the formations.

By the time the Cretaceous formations of the New Jersey coastal plain sequence were deposited, the Atlantic Ocean had essentially attained its present form. The thickening of the sedimentary wedge in the down-dip (seaward) direction and the increase of dips down-section are consistent with the formation of a sedimentary wedge along a subsiding, passive continental margin. The formation of this sequence was periodically interrupted by periods of regression and/or regional uplift, but the overall recorded history is one of gradual subsidence, and infilling of a sedimentary basin.

3.2.5 Engineering Characteristics

Table 3-3 summarizes the engineering characteristics of the geologic formations in the vicinity of the BOMARC Missile Site. The two formations having surface expression at the BOMARC Missile Site are the Cohansey Sand and the Kirkwood formations. Both of these formations are moderately to well sorted and are poorly consolidated. As a result, these two units possess poor slope stability but good to excellent internal drainage. They also provide good foundation support and pavement support.

3.2.6 Geologic Hazards

The region surrounding the BOMARC Missile Site is tectonically quiet based on a review of geologic maps and literature published for the region. U.S. Geological Survey maps do not indicate any major faults on or near the site (Minard and Owens, 1962; Lyttle and Epstein, 1987).

Seismic activity in the area has historically been slight to moderate. There have been no severe earthquakes (i.e, causing severe damage to dikes, roads, or other structures) in the past 200 years. However, there have been several small earthquakes with epicenters within 50 miles of the site in the past 100 years (as further described in Volume 3, Appendix 3-1, Section 2.1.4) (Stover *et al.*, 1987). The strongest such earthquake occurred in 1927, approximately 50 miles to the northeast of the facility. This earthquake measured VII on the Modified Mercalli (MM) Scale, and was strong enough to break windows, and crack chimneys and walls to some extent. In 1938, an earthquake of MM magnitude V took place in the region with its epicenter located about 10 miles northwest of the present BOMARC Missile Site. An earthquake of MM magnitude V is strong enough to be felt by most people, and may overturn small or unstable objects. It may also cause some minor damage, such as broken dishes or glassware. In 1982, another earthquake with an MM magnitude of V occurred about 25 miles west of the facility. A number of smaller earthquakes have occurred in the vicinity of the BOMARC Missile Site within the last century. However, it should be noted that even the strongest of these earthquakes was not strong enough to cause more than very minor damage, such as broken windows and dishes.

3.2.7 Geologic Resources

The geologic resources of Ocean County, New Jersey include sand, gravel, ilmenite, and glauconite. The Cohansey Sand Formation contains large quantities of mortar sand and gravel (Minard and Owens, 1962). Both the Cohansey Sand and the Kirkwood Formations contain useful deposits of ilmenite. The largest deposits of ilmenite are located on the Fort Dix Military Reservation.

Deposits of glauconite in the coastal plain region have been mined for use as fertilizer. Glauconite deposits contain up to eight percent available K_2O, and were used extensively in the nineteenth century before European potash became plentiful. In addition to use as a fertilizer, glauconite has also been used as a water softening agent in Sewell and Medford, New Jersey.

Table 3-3
Engineering Characteristics of Geologic Formations Near the BOMARC Missile Site

Formation	Slope Stability	Internal Drainage	Foundation Support	Pavement Support	Use
Cohansey Sand	Poor	Excellent	Good	Good	Mortar sand, concrete aggregate, retaining walls, borrow
Kirkwood	Poor	Good	Good	Good	Retaining walls, borrow, fill, molding sand
Manasquan	Fair	Fair	Fair	Poor to Fair	Fill, source of glauconite
Vincentown	Poor	Good	Good	Good	Borrow, asphalt, sand
Hornerstown Sand	Good	Fair	Good	Fair	Fill, source of glauconite
Red Bank Sand (upper member)	Poor	Good	Good	Good	Borrow
Red Bank Sand (lower member)	Good	Poor	Good	Fair	Fill, source of glauconite
Navisink	Good	Poor to Fair	Good	Fair	Fill, source of glauconite
Mount Laurel Sand	Good	Good	Good	Good	Borrow, asphalt, sand
Wenonah	Poor to Fair	Fair to Good	Good	Good	Fill, molding, sand
Marshalltown	Poor to Fair	Poor to Fair	Fair	Fair	Fill

Source: Battelle, 1988.

Several formations (such as the Manasquan and the Mount Laurel Sand) contain significant amounts of P_2O_5 in the form of apatite pellets. Soils formed from exposures of these formations (such as are present several miles to the west of the site) are agriculturally very productive.

3.2.8 Surficial Geology

The surficial geology in the BOMARC Missile Site vicinity is characterized via descriptions of the unconsolidated rock deposits, soils, and test pits.

3.2.8.1 Unconsolidated Rock Deposits

Much of the Pinelands region is overlain by a thin, discontinuous veneer of Quaternary clay, sand, and gravel alluvium. Some of these deposits show evidence of wind scouring from past glaciation periods.

3.2.8.2 Soils

Three types of soil, the Lakewood sand, the Lakehurst sand, and Urban Land soils, are present in the BOMARC Soil ROI (Battelle Columbus Division, 1988; Hole and Smith, 1980) (Figure 3-3). The ROI includes portions of the local geologic setting (the shallow soils of the Cohansey Formation) which have been impacted by the plutonium release.

The Lakewood soil series is the predominant natural soil type at the BOMARC Missile Site. The Lakewood soil is a true podzol, a group of zonal soils possessing an organic mat and a very thin organic-mineral layer over a gray, leached A2 horizon and a dark brown, alluvial B horizon enriched in aluminum, iron oxides, and organic matter. The upper layer consists of 7 to 10 inches of gray sand, which overlies 20 to 25 inches of dark brown to yellowish brown sand. The soil is coarse grained and excessively drained. It has a low nutrient content and low moisture retention. Infiltration rates range from 0.2 to 6.3 inches per hour. The Lakehurst sand soil is present in the southern portion of the BOMARC Missile Site. It is moderately to poorly drained, sandy soil characterized by high acidity (pH 3.5-5.0), low fertility, rapid percolation, and a permeability ranging from 0.2 to 20 inches per hour. The third soil type found at the site is an Urban Land Unit. By definition, the Urban Land Units are variable in their composition and morphology.

3.2.8.3 Test Pit Data for BOMARC Missile Site Soils

Six test pits (designated TP-A through TP-F) were dug in the area surrounding Shelter 204. The test pits are approximately 2 feet long, 1 foot wide, and between 18 inches and 2 feet deep. Soil samples were analyzed for particle size distribution, pH, organic matter content, and concentration of various cations. The results of these analyses are described below. Soil samples from test pits TP-A through TP-D represent Urban Land soils. TP-E and TP-F samples are from Lakewood (LwB) soils. The locations of the test pits are shown in Figure 3-3.

3.2.8.3.1 Test Pit Descriptions

Test pit TP-A is located north of Shelter 204. Two distinct strata are discernable in TP-A. The upper stratum is present to a depth of six inches. This stratum consists of a dark, brown loam (7.5 YR/4 – Munsell color code) containing medium-grained sand, some organic matter, and numerous fine root hairs. The lower stratum begins at a depth of 6 inches, and extends to a depth of over 16 inches. It is a yellow-brown (10 YR 7/8), medium to coarse grained sand with some 0.5- to 1.5-inch diameter quartz gravel.

Test pit TP-B is located 28 feet north of Shelter 212. Dimensions of TP-B are similar to those of TP-A. As with TP-A, soils frcm TP-B are separated into two distinct strata. The upper stratum ranges from the surface to a depth of two inches and is composed of a dark brown (10 YR 4), medium-grained sandy loam. The lower stratum extends to a depth of over 16 inches, and is essentially identical to the lower stratum in TP-A.

Test pit TP-C is located 33 feet west of Shelter 102. The upper soil stratum ranges to a depth of two inches, and is composed of a dark brown (10 YR 3/2), medium-grained sandy loam with some organic matter and fine root hairs. The lower stratum extends to over 16 inches in depth, and is composed of a yellow-brown (7.5 YR 7/8), medium- to coarse-grained sand mixed with some gravel.

Test pit TP-D is located approximately 80 feet south of the southwest corner beam of Shelter 105. The soil from this test pit is essentially identical to that of TP-C.

Test pit TP-E is located along the drainage ditch to the south of the missile shelters (see Figure 3-3). Only one soil stratum was identified in this test pit. This stratum consists of a medium to dark red (2.5 YR 5/8), fine-grained sand containing some silt and very little gravel. Less than one inch of loam or topsoil was found at this location. TP-E is located within the area mapped for the Lakewood soil series.

Test pit TP-F is located 100 feet north of the site drive, and 100 feet west of Route 539. Two strata were identified in this test pit. The upper stratum extends to a depth of approximately seven inches. This stratum is a dark brown (7.5 YR 3/1), fine- to medium-grained sand. The lower stratum is a medium red (2.5 YR 5/8), fine-grained sand with very little silt and no gravel.

Soil samples from Test pits TP-A through TP-D were all dry. Soils from Test pits TP-E and TP-F were slightly moist.

3.2.8.3.2 Results of Laboratory Analyses

Table 3-4 shows the particle size distribution for soil samples taken from each of the test pits, as well as the size distribution for a typical Lakewood soil (Hole and Smith, 1980). The Lakewood soils from TP-E and TP-F contain a larger fraction of fine sand relative to most of the Urban Land soil samples. None of the samples contains more than 15 percent of soil particles smaller than silt. Over 80 percent of the soil from each sample is medium to fine grained sand, indicating that the bulk of soil material occupies a narrow size range. Due to the

Table 3-4
Particle Size Distribution for Test Pit Samples

Size Classification	Sieve Size	TP-A	TP-B	TP-C	TP-D	TP-E	TP-F	Lakewood Soil
		Percent Passing for Various Soils						
Gravel	3/4 in. (19.1 mm)			100		100		
	3/8 in. (9.52 mm)	100	100	99	100	99		
Coarse Sand	No. 4 (4.76 mm)	98	98	95	96	99		95-100
	No. 8 (2.37 mm)	93	93	89	92	98		
Medium Sand	No. 10 (2.00 mm)	92	90	87	90	98	100	90-100
	No. 16 (1.19 mm)	88	82	81	82	97	98	
	No. 30 (0.59 mm)	79	59	65	57	94	89	
Fine Sand	No. 40 (0.425 mm)	67	45	50	42	85		40-90
	No. 50 (0.297 mm)	51	28	32	22	74		
	No. 100 (0.149 mm)	17	10	11	9	16		
Silt	No. 200 (0.074 mm)	12	7	7	6	13	8	0-12
	0.037 mm	12	7	7	6	13	8	
	0.019 mm	10	6	7	6	14	7	
	0.009 mm	9	6	6	6	14	6	
Clay	0.005 mm	9	6	5	5	13	6	
	0.0002 mm	6	4	5	5	13	4	
Colloids	0.0001 mm	5	4	5	4	12	4	

sandy nature of these soils, they are all excessively well drained. The Lakewood soil is highly permeable (6-20 inches per hour), and is not subject to periodic flooding.

Although the particle size distribution for the Lakewood and Urban Land soils is fairly similar, the natural Lakewood soil is markedly more acidic than the urban soil. The Urban Land samples have a pH ranging from 5.78 to 6.65. In contrast, the Lakewood soils have a pH ranging between 4.04 and 4.68. Other soil parameters analyzed did not show consistent variations between the Urban Land soils and the Lakewood soils. The range of values determined for the cation and organic content for the soils is expressed in Table 3-5 . Overall, the Lakewood soils contain less calcium and more iron than the Urban Land soils. In all other respects, these two soil units are fairly similar.

Table 3-5
Chemical Analysis of BOMARC Missile Site Soil Samples

Analyte	Lakewood Soil	Urban Land Soil
Aluminum	520 - 1490 μg/g	540 - 1090 μg/g
Calcium	30 μg/g	110 - 360 μg/g
Iron	1650 - 2530 μg/g	433 - 1040 μg/g
Magnesium	4 - 11 μg/g	6 - 12 μg/g
Organic Matter	4.6 - 17.6%	7.9 - 18.9%
Moisture	4.0 - 8.0%	1.4 - 6.0%

3.2.8.4 Soil Properties Important in Plutonium and Americium Migration

This section focuses on the primary soil mechanisms or properties which relate to plutonium mobility in soil. These properties include soil adsorption capacity, soil pH, soil organic matter content and soil particle size distribution. The statements and conclusions appearing in this section are based on a review of the current literature.

Once plutonium or americium is released and enters the soil or sediment environment they are strongly adsorbed by surface soil or sediment (Hakonson, *et al.* 1981; Tamura, 1977; and Price, 1973). Evidence exists which indicates soil retention capacity of plutonium actually increases over time (Tamura, 1977). Soil adsorption occurs as the plutonium ions become bound with iron and manganese oxides associated with soil particles (Tamura, 1977).

Americium is generally affected by the same soil parameters (particle size, pH, organic content, etc.) but does not appear to be sensitive to the same ranges of these parameters as plutonium. For example, there seems to be no relationship between size range of soil particles and americium adsorption capacity (Yamamoto, *et al.*, 1980). Detailed studies of the interaction between ^{241}Am and soils are lacking. However, major differences in the environmental behavior of ^{241}Am as compared with that of plutonium would be expected (Hanson, 1980).

<u>Soil pH</u>: In environmental soils with pH ranges from pH 2 to pH 8, over 99 percent of plutonium experimentally added was adsorbed to soil particles. Experimental results suggest that maximum soil sorption occurs at pH 5.5 (Bondietti and Tamura, 1980). Variations in soil pH within the range from pH 2 to pH 8 do not appear to alter the potential of soil to adsorb plutonium, but rather it determines which ionic species of plutonium will be adsorbed to soil particles.

<u>Organic Content of Soil</u>: Soil organic content is also an important soil characteristic which can influence plutonium migration. Certain organic ligands (including fulvic and humic acids) can form complexes with plutonium released in the topsoil. Some of these Pu-organic acid ligands (e.g., humic acid) can reduce plutonium-soil mobility (Livens, *et al.*, 1987). According to analyses performed by Bondietti, *et al.*, (1975) up to 15 percent of plutonium added to soil was

found in association with organic matter. Complex formation of plutonium and smaller organic ligands can increase plutonium's bioavailability to plants (Livens, *et al.*, 1987, and Wilding and Garland, 1982).

Particle Size: Based on a review of the literature, plutonium is preferentially bound to silt and very fine sand size particles. Data (from the literature) supporting this are provided as Table 3-6. In Table 3-6, soil fraction refers to the weight percentage of each size class. Activity fraction refers to a percentage of the plutonium activity associated with the corresponding size class. The soil activity factor is defined as being "the activity per unit weight of mass for each size fraction" (Bondietti and Tamura, 1980). At least one study demonstrated that the clay-size soil particles adsorbed a significant percentage (48.5 percent) of introduced plutonium (Yamamoto, *et al.*, 1980).

Table 3-6
Soil Fraction Calculated From Soil Activity Factor, Depositional Factor, and Resuspendible Fraction

Size, Microns(μm)	Soil Fraction	Activity Fraction	Soil Activity Factor
	Nevada Test Site (Area 13)[1]		
<2 (clay)	0.04	0.03	0.75
2 to 5 (silt)	0.03	0.04	1.33
5 to 125 (silt to v fine sand)	0.43	0.92	2.19
	0.50	0.99	4.27
	Rocky Flats[1]		
<2 (clay)	0.12	0.28	2.33
2 to 5 (silt)	0.04	0.14	3.50
5 to 125 (silt to v fine sand)	0.34	0.49	1.44
	0.50	0.91	7.27
	Mound Laboratory[2]		
<2 (clay)	0.19	0.46	2.62
2 to 4 (silt)	0.09	0.14	1.56
4 to 125[3] (silt to v fine sand)	0.72	0.40	0.56
	1.00	1.00	4.54
	Oak Ridge National Laboratory[1]		
<2 (clay)	0.29	0.40	1.38
2 to 5 (silt)	0.10	0.09	0.09
54 to 125 (silt to v fine sand)	0.59	0.51	0.86
	0.98	1.00	3.14

[1]Source: Bondietti and Tamura, 1980.
[2]Source: Muller and Sprugel, 1976.
[3]Assumes particles greater than 4 μm to be no greater than 125 μm.

Historical Plutonium Migration: In-situ migration of plutonium (independent of erosion, mechanical, or biological input) through soil occurs at a relatively slow rate. The migration velocities of two plutonium species, PuO_2 and $Pu(NO_3)_4$, were determined to be 0.8 cm per yr and approximately 0.008 cm per yr, respectively (Jakubick, 1975). Given this rate of migration, it is self-evident why most soil profiles of fallout document plutonium only in the uppermost 10 to 30 cm (Essington and Fowler, 1977). Americium may be slightly more mobile in soil, but its presence at five or six cm below the surface is still very low (Yamamoto, *et al.*, 1980). Even in sandy soils, the migration rate appears to be very slow, since plutonium migration did not exceed 30 cm below the surface in sandy soil profiles studied in Italy, New York and Massachusetts (Essington and Fowler, 1977). In the absence of fissures, cracks, or other migration conduits, plutonium migrates very slowly because it is "strongly bound to soil material" (Essington and Fowler, 1977). No evidence of cracks and fissures in the soils was observed during the RI/FS or EIS site investigation.

Since it seems unlikely that plutonium is mobile in soil, or in solution form (Romney, *et al.*, 1970), and since plutonium and americium are strongly adsorbed by soil just after environmental release, erosion would seem to be the primary transport medium of plutonium (Hakonson, *et al.*, 1981). Both wind and water erosion are capable of acting on soil particles associated with plutonium adsorption.

3.2.8.5 Quantitative Methods for Prediction of Soil Loss and Off-site Transport

Of all the properties of soils, it appears that only particle size distribution is significant in prediction of soil loss due to remedial activities at the BOMARC Missile Site.

Adsorbed plutonium ions and soil particles would move together during an erosional event. This unit would be heavier than a single clay-silt particle because plutonium is dense. Greater energy would be required for entrainment and transport of this particle type as compared to other clay-silt particles. It is expected that soil erosion during remediation could occur due to movement of water or wind across the site.

A literature search was conducted on current soil erosion models. No models consider all the soil properties found to be important in plutonium migration. Also, no models were found that consider movement of a plutonium-soil particle unit. Thus, to predict soil loss, a basic estimation technique, the Universal Soil Loss Equation (USLE), was used to predict sheet erosion of the soil particles at the BOMARC Missile Site.

The USLE is a widely used model which uses factors affecting erosion losses to calculate soil loss per unit area. The equation is:

$$A = RKLSCP$$

where:

A = computed soil loss per unit area,
R = rainfall,
K = soil erodibility,
L = slope length,
S = slope gradient,
C = crop management (vegetative cover), and
P = erosion - control practice.

Although there are limitations in applying the USLE to the BOMARC Missile Site, it seems to be a viable approach for a rough approximation for the amount of soil erosion that could be associated with remedial activities at the BOMARC Missile Site. Using the USLE may be most appropriate for estimating soil loss for the next few decades. However, in the more distant future this approach would not be useful, as there would be too many uncertainties in the USLE.

3.2.8.6 Soil Contamination

Soil contamination has been documented at the BOMARC Missile Site as described in the RI/FS. A variety of types of soil samples were collected as part of the RI/FS. Soil samples were collected at various depths and locations, including the area around Shelter 204 and nearby shelters, and the drainage ditch beneath the concrete pad. These are areas that historically show radioactive contamination, and are random areas not believed to be contaminated. Sampling has repeatedly demonstrated that higher levels of radioactive contamination are present in the area of the drainage ditch than over the rest of the site. Some samples had elevated levels of volatile organic and semivolatile organic compounds, as well. Detailed descriptions of soil sampling and sample analyses are discussed in the RI/FS.

3.3 Hydrology

Hydrologic pathways are important potential off-site transport routes for radioactive materials at the BOMARC Missile Site. This includes both surface water pathways and groundwater pathways. The hydrologic ROI is described, and the hydrologic setting of the BOMARC Missile Site is characterized in this section.

3.3.1 Region of Influence

The ROI for the BOMARC Missile Site includes those portions of the hydrologic system where potential impacts may have occurred due to: (1) the initial release of radioactive material, and (2) subsequent migration of radioactivity along identified surface water and groundwater pathways. The ROI depends on the source locations and physical controls that affect the rate, magnitude and areal extent of contaminant migration from these locations. The source locations and controls are discussed below, followed by a description of the ROI for surface water and groundwater.

3.3.1.1 Source Locations and Controls of the Region of Influence

Four specific locations have been identified as probable sources of plutonium at the BOMARC Missile Site. One other nonspecific location has also been identified as a probable plutonium source. The current, known plutonium sources include the areas described below and, for those sources with known locations, shown in Figure 3-7:

- Shelter 204 - the surface area and the area immediately around the shelter contaminated at the time of the accident

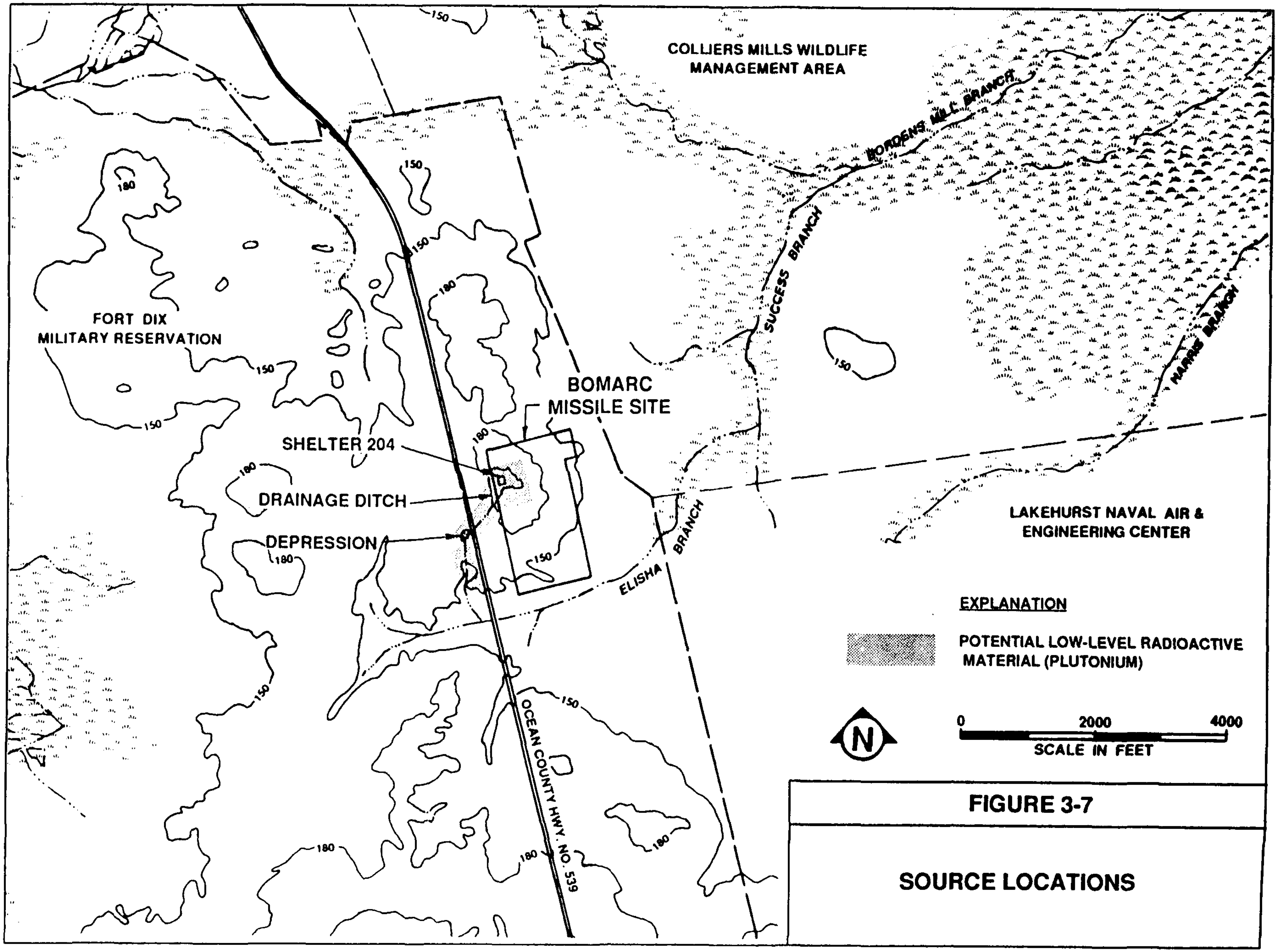

FIGURE 3-7

SOURCE LOCATIONS

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- Drainage Ditch - extending southwesterly from the launch area to Ocean County Highway No. 539

- Surface Depression - located to the west of the Ocean County Highway No. 539 and downstream of the drainage ditch

- Downwind Area - the land area located to the southwest that may have received radioactive material by wind transport at the time of the accident

- Missile Launcher - presumed to be buried somewhere in the site vicinity, but its location is not known at present.

From these source locations, radioactive material may have been mobilized in the hydrologic system along surface water and groundwater pathways. Physical controls on the surface water pathway which influence the mobilization of radioactive material are as follows:

- Surface Coverings - plutonium-contaminated surfaces at the site, primarily the structures and the ground surface, have been covered by paint, asphalt or concrete, thus minimizing contact with the air, rain, and surface water

- Surface Water Control - road culverts and depressions located along the drainageway (including the earthen berm which was temporarily constructed across the ditch) created ponded surface runoff at the time of the accident, and thereby enhanced seepage into the ground

- Secondary Sources - residual plutonium contamination in surface soils at former ponding/seepage locations and in the wind drift zone are potentially exposed to present and future surface water runoff over these areas.

Physical controls on the groundwater pathway which influence the mobilization of radioactive material are as follows:

- Recharge - infiltration of rain water through plutonium-contaminated soils at source locations (except those areas covered by impervious surfaces which inhibit infiltration)

- Groundwater Flow - hydraulic conductivity of the underlying material and the hydraulic gradient of the groundwater flow paths located downgradient of identified sources

- Baseflow Contributions - proximity of surface water channels that may receive groundwater discharge from the flow paths affected by upgradient sources.

3.3.1.2 Surface Water

On the basis of available topographic maps and the proposed RI/FS Work Plan (Battelle, 1986), the principal surface water ROI as defined here includes two areas. Area 1 is the drainageway extending from the launch area through (and including) the depression located on the west side of Ocean County Highway No. 539 (Figure 3-8). Testing was done as part of the RI/FS to confirm the presence of plutonium along this drainageway. Area 2 extends from this depression to the intersection of Elisha Branch and Success Branch, a distance of approximately 6,000 feet. Area 2 also includes the channel downstream to the confluence of Success Branch and Bordens Mill Branch, which is a distance of approximately 4,000 feet. The surface water pathways in Area 2 are considered to be within a secondary zone of influence where plutonium contamination may have been transported downstream beyond the depression in Area 1.

3.3.1.3 Groundwater

Since limited groundwater level information is available, only the ROI for shallow groundwater in the Cohansey aquifer can be interpreted for the BOMARC Missile Site. Deeper groundwater flow and a broad zone of influence is inferred, assuming downward flow does exist at the site. However, no data are currently available to determine actual deep flow paths from the identified source areas. The shallow and deep ROIs are shown in Figure 3-8 as Area 1 and Area 2, respectively.

The width and length of each ROI is based on interpreted groundwater flow directions and the potential for discharge along the Elisha Branch and the Success Branch. The shallow ROI extends from Shelter 204 to the southwest and encompasses the westerly drainageway which may contain source areas of plutonium. The shallow ROI also extends to the northeast and includes the area in the downgradient direction of groundwater flow. The shallow ROI is interpreted as terminating at the Elisha Branch as shallow groundwater discharge to the watercourse and its associated wetlands.

The deeper ROI extends from the site to the east and overlaps, in part, with the shallow zone. The deeper zone corresponds to potential contamination derived from all sources currently identified at the BOMARC Missile Site. The downgradient extent of the deeper ROI is shown to coincide with the shallow zone, although it is possible that deep groundwater in the Cohansey-Kirkwood aquifer travels further down the watershed before discharging upward to the surface. A deeper and more extensive downgradient ROI was considered unnecessary because groundwater monitoring data from the RI/FS did not show significant plutonium contamination beneath the site.

An ROI is not projected into any of the deeper aquifer systems below the Cohansey-Kirkwood Formation. The Vincentown, Wenonah-Mount Laurel, Englishtown, and Potomac-Raritan-Magothy Formations are separated from the surficial aquifer by one or more confining beds of silt and clay.

3.3.2 Surface Water Hydrology

The BOMARC Missile Site is located near the northern boundary of the New Jersey Pinelands, in the outer portion of the Atlantic Coastal Plain Physiographic Province. The coastal plain and Pinelands terrain is characterized by gently rolling hills and low-lying, poorly drained wetland environments.

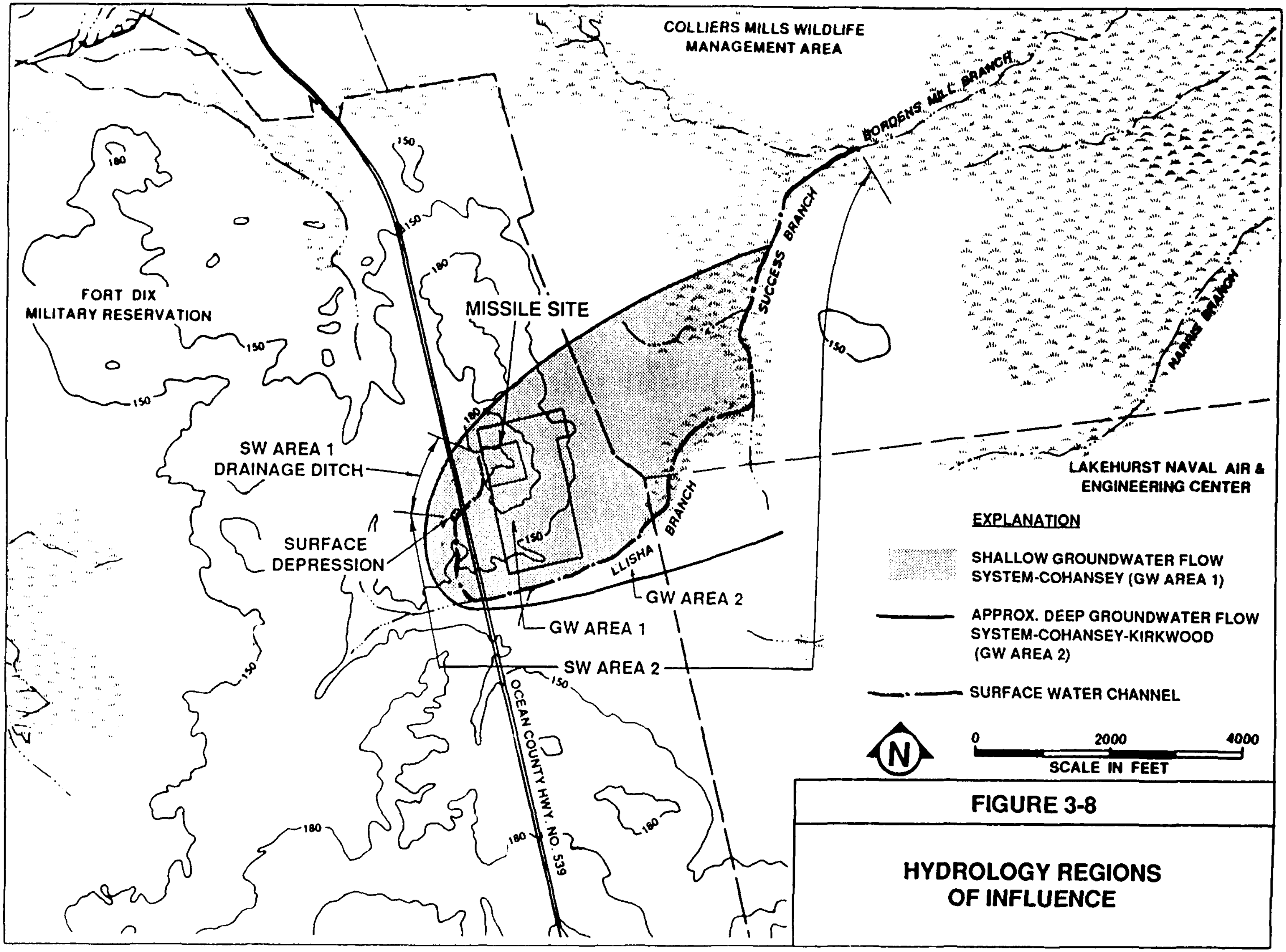

FIGURE 3-8

HYDROLOGY REGIONS OF INFLUENCE

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3.3.2.1 Surface Water Features

The BOMARC Missile Site occupies one of a series of north-south trending hills or highlands which are flanked to the east and west by broad lowlands, i.e., swamps, marshes, and bogs (see Figure 3-9). The highlands are dry and sandy, which promote rapid infiltration of water, recharging groundwater, and low runoff. The lowlands are swamps which release water slowly to drainageways as base flow. Base flow represents the portion of stream discharge derived from groundwater seepage.

There are no perennial streams or other surface water bodies on the dry, upland soils of the BOMARC Missile Site. The principal surface water features associated with the site are the natural intermittent streams that drain the nearby low wetlands of the Pinelands. The majority of the surface runoff from both the missile launch area and support facilities drains to the west, south, and east, eventually reaching Elisha Branch. From Elisha Branch, surface water flows into Success Branch then into Bordens Mill Branch, and from there into Ridgeway Branch (Figure 1-2). Ridgeway Branch empties into the Toms River, which ends at Barnegat Bay. Major water bodies in the watershed include Success Lake and Horizon Lake.

In the vicinity of Shelter 204, surface water resulting from precipitation flows in a westerly direction over concrete and asphalt, and is collected by a south flowing drainage ditch, which borders the western edge of the paved area. The south flowing ditch carries storm runoff beyond the site boundary to the Elisha Branch. Drainage into the south flowing ditch is intermittent and depends on the intensity and duration of precipitation events. The amount of flow that eventually reaches Elisha Branch varies due to evapotranspiration and infiltration.

Immediately north of Shelter 204 are two parallel, east-west trending roadways, separated by a grass-covered median strip sloped to the west for drainage through a culvert under another, north-south trending roadway. The ditch turns north and then east around the site, eventually emptying into Success Branch downstream from its confluence with Elisha Branch. However, none of the local drainage from the area immediately around Shelter 204 would end up in this north-flowing ditch.

3.3.2.2 Watershed Drainage Areas

Watershed size is a primary factor in determining the volume and persistence of flow into drainage channels, and influences the type and magnitude of flooding and the nature of sediment transport. The local watershed containing the BOMARC Missile site drains to a south-flowing drainage ditch which is a tributary to Elisha Branch. This is a first order stream, which means it has no tributaries, and does not have a large enough contributing area to generate perennial flow. The drainage area of this ditch, upstream from the culvert beneath Ocean County Route 539 (shown in Figure 3-9), has been estimated to be 22 acres. Much of the surface area of the local watershed is covered by relatively impervious asphalt and concrete surfaces in the launch area. The man-made physical setting within the watershed promotes rapid runoff of rainfall and diminished potential infiltration to groundwater.

Estimated watershed drainage areas for Elisha Branch and the watercourses downstream from the local watershed are given in Table 3-7.

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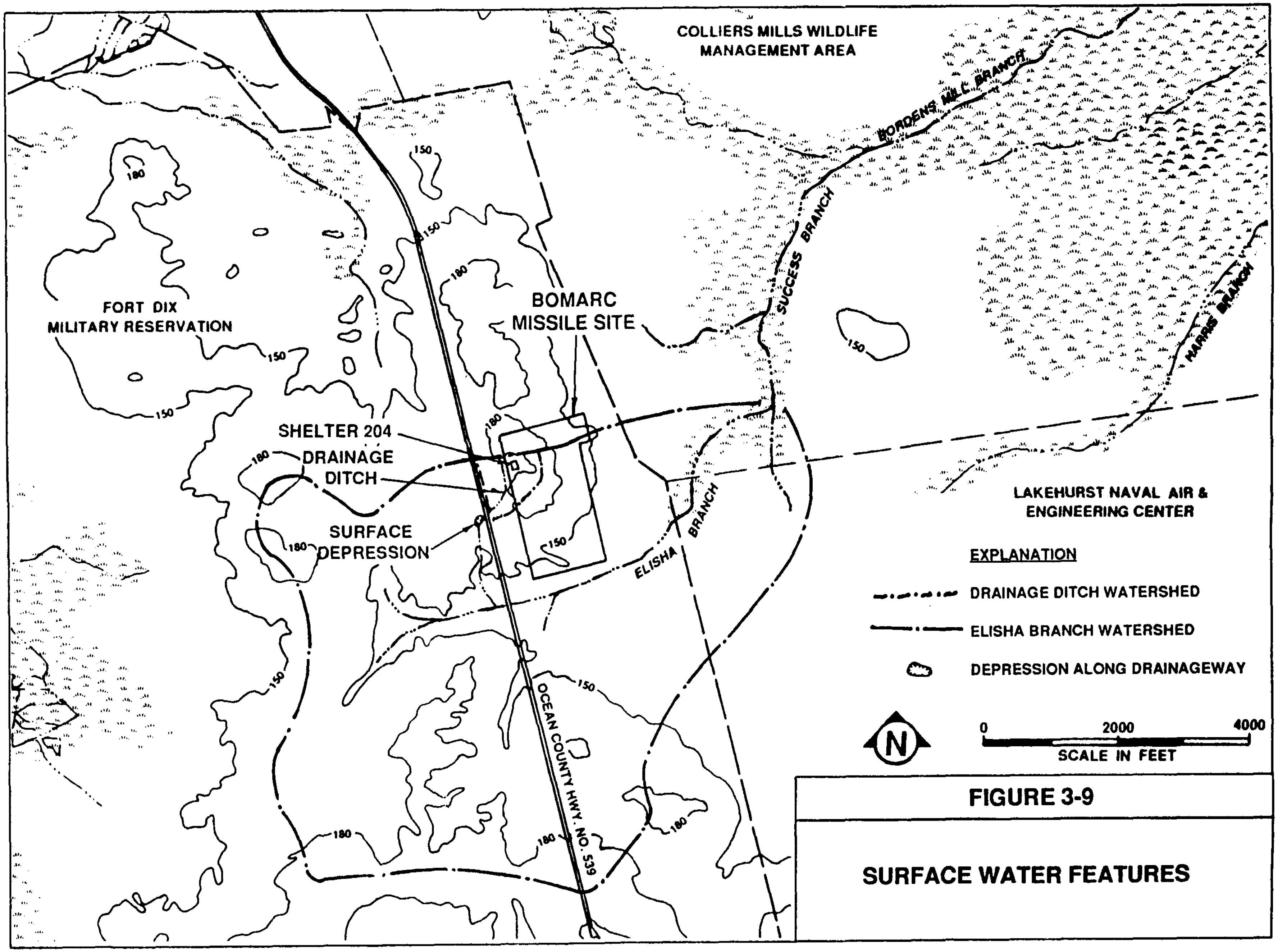

FIGURE 3-9

SURFACE WATER FEATURES

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Table 3-7
Estimated Runoff from Various Drainage Basins

Branch	Drainage Area (square miles)	Estimated Flow (cubic feet per second)
Elisha (at mouth)	1.22	1.9
Success (at mouth)	2.00	3.1
Bordens Mill (at mouth)	4.10	6.4
Ridgeway (at Pine Lake)	33.1	51.3

Source: Velnich, 1984.

3.3.2.3 Surface Water Flow

Surface water runoff and stream channel flow are an important potential transport pathway for radionuclides. Douthitt (1989) suggests that the average flow rate for streams in the Pinelands region is approximately 1,000,000 gallons per day per square mile of drainage area. This is equal to 1.55 cubic feet per second per square mile (csm) of drainage area, which is within the expected range of gauged streams in the Pinelands region (see Volume 3, Appendix 3-2, Section 2.1.3).

Accepting 1.55 csm as a reasonable estimate of average flow rates for streams in the watershed containing the BOMARC Missile Site, average discharge was calculated for the different watershed areas presented in Table 3-7.

A preliminary estimate of average streamflow coming from the local watershed area of 0.1 cubic feet per second is presented in Section 2.1.3 of Volume 3, Appendix 3-2. This estimate uses accepted values of annual rainfall for the Pinelands region and a conservative estimate that 90 percent of the rainfall would become surface runoff. This rate of flow coming from a 22-acre watershed equals 2.92 csm, which is also within the expected range for the area. However, flow in the drainage ditch is not continuous and is calculated so here solely for comparison purposes.

Because the local watershed is so small, and the drainage ditch is a first order tributary, flow in the channel is expected to occur only due to a rainfall event, or an artificial discharge of water into the channel. As a result, flow in the channel would be periodic, with relatively small peak flow rates that would take place only a small percentage of time on average. Therefore, potential transport of sediment within the channel would be episodic, and likely to proceed at a relatively slow rate. Furthermore, delivery of sediment to the channel for possible transport downstream would not be considered likely unless the asphalt and concrete surfaces were disturbed and no perimeter controls were employed.

3.3.2.4 Local Flooding

The BOMARC Missile Site is not expected to have any problems with local flooding. Shelter 204, the accident site, is located very near the drainage divide in a small, first order watershed. The watershed has low relief and no real channel adjacent to the site to accumulate runoff and provide a setting for floods. Downstream on Elisha Branch, drainage areas are large enough to produce perennial flow and channels more prone to flooding. However, flooding would cause environmental concern on these channels only if flood waters are carrying sediments with radionuclides attached.

3.3.2.5 Water Quality

No general surface water quality data is available for the local drainage ditch originating near the BOMARC Missile Site, or in Elisha Branch. Regional water quality data for the Pinelands area provides the best available information to suggest what the general water quality conditions in Elisha Branch are likely to be. Table 3-8 presents the common ranges for water quality parameters for the surface water and groundwater of the Pinelands Region.

Natural surface water in the Pinelands is acidic with pH commonly between 3.5 to 4.5 pH units. This is due to the acidic nature of the rainfall, the buffering capacity of sandy soils, and the pine forest environment which promotes an acidic environment. These waters also tend to have some coloration to them resulting from organic tannins and iron precipitates in the water. However, the water is still considered to be of good quality, because of the low levels of other constituents (Rhodehamel, 1970).

The Toms River watershed, which contains the Elisha Branch and its tributaries, drains a large portion of the Pinelands area and contains good to excellent water quality. This is in spite of trends which indicate that water quality is declining with regard to certain parameters such as the temperature and nitrogen content (Robinson, 1986).

Site specific surface water quality was assessed as part of the RI/FS (see Section 4.1.3.2 of the RI/FS). A total of 17 surface water samples were collected during the field effort on the BOMARC Missile Site. Filtered and unfiltered environmental surface water samples were collected from 15 locations around Shelter 204. Two surface water samples were also collected, one each, from the power and communication bunkers in front of Shelter 204.

No surface water is found on the BOMARC Missile Site except during heavy rainstorms. Of the surface water samples collected, 14 were collected from around Shelter 204 during heavy rainstorms. The last sample was collected south of the BOMARC Missile Site from standing water in the swampy area near the headwaters of the Elisha Branch.

Three unfiltered samples showed low levels (4 to 5 pCi per L) of gross alpha activity, all of which were well below the State and Federal Standard of 15 pCi per L. No gross alpha activity was detected in any of the filtered samples collected, indicating that the alpha activity found in the unfiltered samples was due to suspended particles rather than to dissolved material.

Table 3-8
Physiochemical Properties of Pine Barrens Region Water[a]

	Surface Water			Groundwater		
	Minimum	Maximum	More Common Extreme Value[c]	Minimum	Maximum	More Common Extreme Value[c]
Period of Collection	**circa 1920-1925 to 1967**			**circa 1951 to 1967**		
Silica (SiO_2)	0.14	17.00	—	1.10	42.00[b]	10.0
Aluminum (Al)	0.0	0.6	—	0.00	10[b]	1.8
Iron (Fe)	0.00	7.1	—	0.00	49[b]	0.5-11.0
Manganese (Mn)	0.00	0.77	—	0.00	2	—
Calcium (Ca)	0.0	26	—	0.0	90[b]	10
Magnesium (Mg)	0.0	7.8	—	0.0	18[b]	4.4
Sodium (Na)	0.4	28	—	0.9	26[b]	5.7
Potassium (K)	0.0	7	—	0.0	6.2[b]	4
Lithium (Li)	—	Trace	—	—	0.4	—
Bicarbonate (HCO_3)	0.0	72[b]	10	0.0	146[b]	10
Carbonate (CO_3)	—	0.0	—	—	0.0	—
Sulfate (SO_4)	0.8	85	—	0.0	45[b]	15
Chloride (Cl)	0.0	60[b]	8	1.8	34[b]	7
Fluoride (F)	0.0	1	—	0.0	4[b]	0.3
Nitrate (NO_3)	0.0	8.9	—	0.0	37[b]	7
Phosphate (PO_4)	0.00	0.51	—	—	0.0	—
Boron (B)	Trace	0.10	—	0.00	0.14	—
Carbon Dioxide (CO_2)	0.00	0.02	—	2.2	25	—
Dissolved Solids						
Calculated	—	—	—	—	—	—
Residue on Evaporation at 180°C	17	195[b]	50	13	135[b]	35
Hardness as $CaCO_3$	2	78[b]	25	0.0	70[b]	13
Noncarbonate Hardness as $CaCO_3$	0.0	71[b]	15	0.0	52[b]	18
Alkalinity as $CaCO_3$	—	—	—	—	—	—
Total Acidity as H^{+1}	0.1	0.4	—	0.0	0.6	—
Specific Conductance (micromhos/cm 25°C)	24	364[b]	90	15	315[b]	45
pH (standard units)	3.8	8.0[b]	7	4.2	7.3[b]	5.8
Color	0.0	450[b]	3-100	1	1,300[b]	10
Temperature (°C)	0	30[b]	24	9	21[b]	14
Dissolved Oxygen (DO)	4.2	10.3	—	—	—	—
Suspended Sediment (in tons/day/mi^2)	0.001	0.24	—	—	—	—

[a] Concentrations are reported in milligrams per liter (mg/l); other properties are reported in units shown in the left column. Table based upon about 7,000-10,000 separate quality of water determinations.

[b] These values are considered to be atypical for the region, and are thought to be influenced by man's activities such as farming, waste disposal, and manufacturing.

[c] Values in these columns are interpreted as being more indicative of the upper and where a range is given of lower and upper values existing in the natural environment.

Source: Rhodehamel, 1970.

Nine unfiltered samples showed low levels (5 to 20 pCi per L) of gross beta activity. In the majority of the samples, there was no beta activity found in solution, and all levels found were below regulatory standards of 50 pCi per L. No activity of any kind (alpha or beta) was detected from samples collected on the concrete pad in front of Shelter 204. The only samples showing alpha activity were unfiltered samples collected from the unlined ditch northwest of Shelter 204, and from a lined portion of the drainage ditch south of Shelter 204 where sediment collects. All samples showing beta activity were collected from locations where either the drainage was unlined or where sediment had a tendency to collect.

The specific isotope(s) providing the source of the alpha and beta activity are not identified but are very likely to be naturally occurring isotopes of uranium, thorium, or potassium and their daughters. The values on the BOMARC Missile Site are comparable to the environmental surface water samples collected in other parts of the Toms River and adjacent basins.

Two surface water samples were collected, one each, from the power and communications bunkers in front of Shelter 204. The sample collected from the power bunker contained 210 pCi per L of plutonium, and the sample from the communication bunker contained 24 pCi per L of plutonium. These bunkers were not sealed with concrete at the time of the missile fire, which could have allowed either contaminated water from the fire fighting effort to drain in, or loose contamination from the manhole covers to fall in when the covers were removed or disturbed. In either case it is not unexpected to find plutonium contamination inside of these underground bunkers. The samples collected during the 1989 field effort were not filtered, so it is not known whether any ^{239}Pu was in solution, or whether it was all suspended in the water.

The power bunker is closer to the center drainage of the street in front of Shelter 204, which may account for the higher levels of ^{239}Pu in that bunker. Water carrying plutonium from the fire fighting, or later runoff from Shelter 204, would have flowed over both bunker covers and may have settled in greater concentrations over the power bunker lid. This would have allowed the water to percolate in, or allowed plutonium particles to lodge against the lid so they could fall in later when the lid was removed. The random nature of grab samples may also be the reason for the different levels of contamination observed in the two bunkers.

3.3.2.6 User Inventory

Surface waters near the BOMARC Missile Site, including Elisha Branch and its immediate downstream watercourses, are not known to be presently in use as a water supply source. Although no water quality data specific to the Elisha Branch are available, the acidity and color of waters typically found in the Pinelands would likely require treatment prior to use as a water supply.

Downstream of Elisha Branch, the Toms River receives effluent from permitted industrial, commercial, municipal, and institutional discharge sources. Ten point-source discharges were reported for the watershed in 1986, yet the water quality at the lower end of the river system has remained clean (Robinson, 1986).

3.3.3 Groundwater Hydrology

This section includes a discussion of: the major aquifers, the unsaturated zone, groundwater monitoring, groundwater flow, groundwater quality, and water use. Knowledge of general hydrogeologic conditions in the New Jersey Pinelands area is good, and groundwater elevations in the BOMARC Missile Site location have been well defined.

3.3.3.1 Aquifer Formations

The New Jersey Coastal Plain is underlain by a thick sequence of unconsolidated layers of sediments ranging in size from clay to gravel. These layers comprise several identifiable aquifers which are separated by confining layers and dip and thicken to the southeast. The regional groundwater gradient found in these aquifers is toward the southeast also, because of the sloping aquifers. A more detailed description of these aquifers is given in Volume 3, Appendix 3-2.

The principal aquifer of concern for potential contamination from radionuclides is the uppermost Cohansey-Kirkwood formation. Distinctions can be made between the Cohansey Sand, which is a coarse-grained sand that overlies the Kirkwood Sand, which is fine- to medium-grained. Flow within the Cohansey sand is generally more rapid than flow within the Kirkwood sand. Local groundwater gradients within the Cohansey-Kirkwood aquifer are not always coincident with the regional gradient direction, and must be determined through local groundwater level measurements.

The confining layer underlying the Cohansey-Kirkwood aquifer is thought to provide an effective barrier to downward seepage of groundwater from the Cohansey-Kirkwood formation. Therefore, potential migration of radionuclides through the groundwater path most likely would be laterally within this aquifer and not vertically into any deeper aquifer. In addition, the finer sediment found in the deeper lying Kirkwood formation limits flow within this unit and favors shallow penetration of recharge water with flow remaining primarily within the upper Cohansey formation.

The hydraulic properties of the upper Cohansey formation are given because radionuclide penetrations is only expected for this upper unit. Even though no site-specific aquifer tests were performed on monitoring wells at the BOMARC Missile Site, some general aquifer characteristics for the Cohansey unit are available. The normal aquifer thickness of the Cohansey is approximately 100 feet. The hydraulic conductivity ranges from 750 to 1,000 gallons per day (gpd) per square foot, typical of well-sorted sands and gravels. The transmissivity ranges from 75,000 to 100,000 gpd per foot and the specific yield generally is less than 25 percent, typical of fine gravel to gravely sand (Rhodehamel, 1970).

Local information on the groundwater conditions comes from a network of 22 groundwater monitoring wells completed in the Cohansey Sand and two inactive water supply wells completed in the Kirkwood Sand (see Figure 3-10). All of the monitoring wells have 15-foot screened sections, and total depths that range from 30 to 67 feet deep. The two water supply wells are installed to a total depth of 100 feet.

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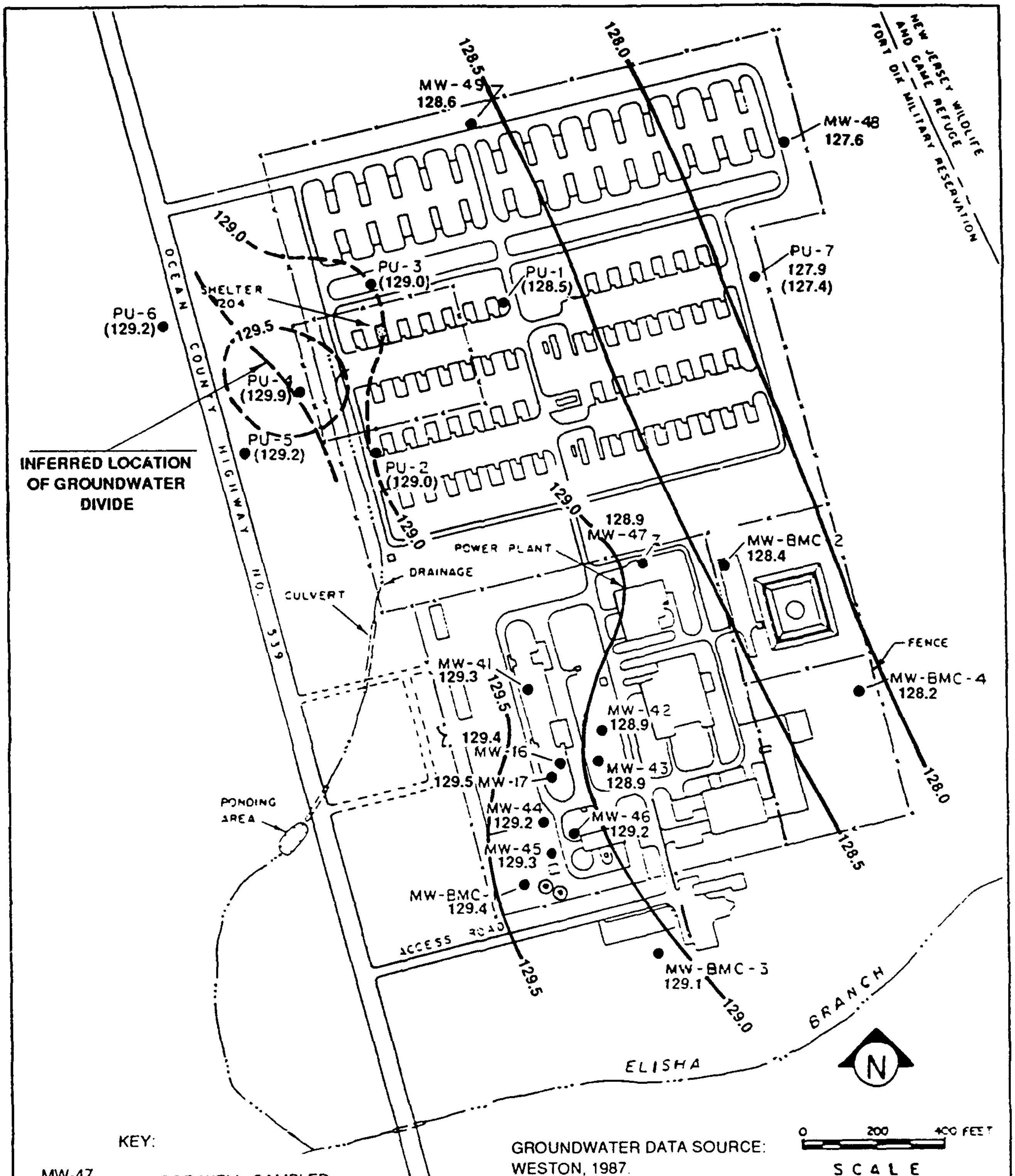

KEY:

● MW-47	MONITOR WELL, SAMPLED
128.7	GROUNDWATER ELEVATION MARCH 1987
(128.7)	GROUNDWATER ELEVATION JULY 1987
⊙	WATER SUPPLY WELL

GROUNDWATER DATA SOURCE: WESTON, 1987.

FIGURE 3-10

GROUNDWATER CONTOUR MAP 1987

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The unsaturated zone as measured in these wells ranges in thickness from about 20 to 55 feet. This unsaturated zone contains a number of lenses of silt and clay which interrupt an otherwise coarse, peımeable sand. The silt/clay lenses slow vertical seepage of recharge water, have a much greater specific retention than the sand, and create localized perched water conditions.

3.3.3.2 Groundwater Flow Characteristics

The Cohansey-Kirkwood Formation is unconfined in the vicinity of the BOMARC Missile Site, but as the formation dips and thickens to the southeast it goes beneath a layer of finer sediments and becomes a confined aquifer system. Upward seepage gradients have been reported within the Cohansey-Kirkwood Formation (Rhodehamel, 1970) and the idealized flow system shown in Figure 3-10 has been suggested. In this diagram, the BOMARC Missile Site would fall within the outer fringes of the upland recharge area, where local recharge of the shallow portions of the aquifer is favored, and the depth of penetration of this recharge water is limited.

Groundwater elevations in the Cohansey Sand have been mapped for the two primary periods of water level measurements, 1987 (Figure 3-10) and 1989 (Figure 3-11). These figures clearly indicate that the groundwater flow direction is to the east-northeast across the BOMARC Missile Site. The general map of upland recharge areas in Volume 3, Appendix 3-2 and these groundwater contour maps collectively suggest that a groundwater divide exists adjacent to Ocean County Route 539. However, no groundwater elevation data to the west of the site is available, and a definitive groundwater divide cannot be established. None-the-less, these groundwater maps show the Elisha Branch as the only surface water receptor for groundwater discharged from the BOMARC Missile Site. Because the monitoring wells on the site are all screened within the Cohansey Sand, no site-specific groundwater elevation data is available for the Kirkwood Formation. Thus, the general assumption (Figure 3-12) that the deeper Kirkwood groundwater flow in the vicinity of the BOMARC Missile Site is parallel to the shallower Cohansey flow, and primarily horizontal, cannot be confirmed or rebuffed.

In the absence of some site-specific aquifer characteristics, general values can be used to estimate groundwater travel rates. A value of 100 feet per day for the hydraulic conductivity was used by Weston (1989). This would be within the normal range of values reported for the Cohansey Sand. A general value of 0.3 also was used for effective porosity, but the site-specific hydraulic gradients and flow paths were employed in calculating expected travel times. Groundwater would be expected to take between 5 and 22 years to reach the Elisha Branch from Shelter 204. This would be representative of groundwater flow without the consideration of any retardation factors which might reasonably be expected to impact the travel rate for groundwater constituents.

3.3.3.3 Groundwater Quality

Limited groundwater quality information is available for the BOMARC Missile Site. The data collected at the site have focused on site-derived contamination (USAFOEHL, 1988; Weston, 1989; The Earth Technology Corporation, 1992) (Table 3-9). Weston has indicated that volatile organic chemicals and plutonium were detected at several monitoring well locations. Plutonium was detected in monitoring wells located to the northeast (PU-7), west (PU-2) and immediately to the north (PU-3) of Shelter 204. Analyses for plutonium in groundwater samples from wells

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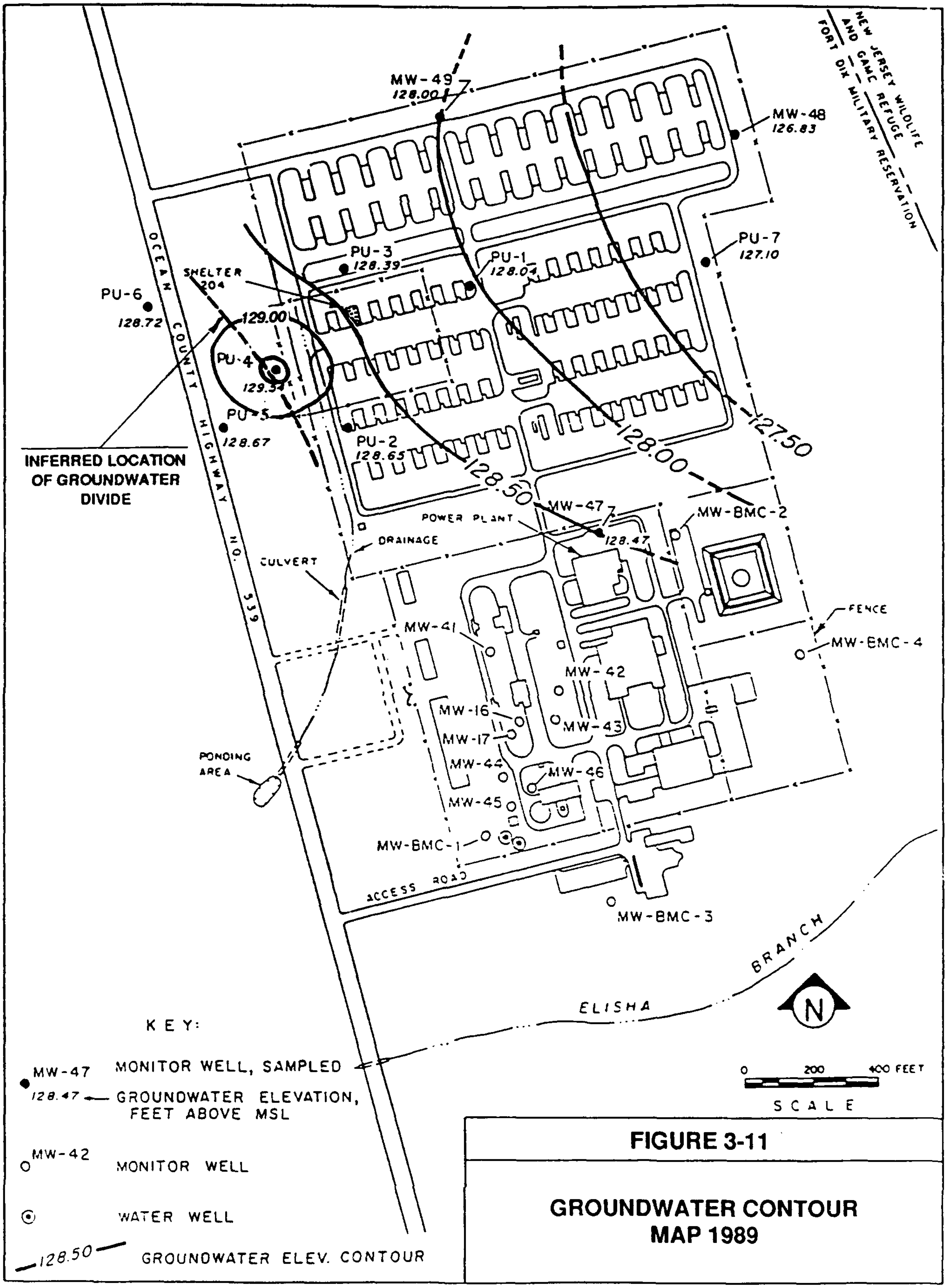

FIGURE 3-11

GROUNDWATER CONTOUR MAP 1989

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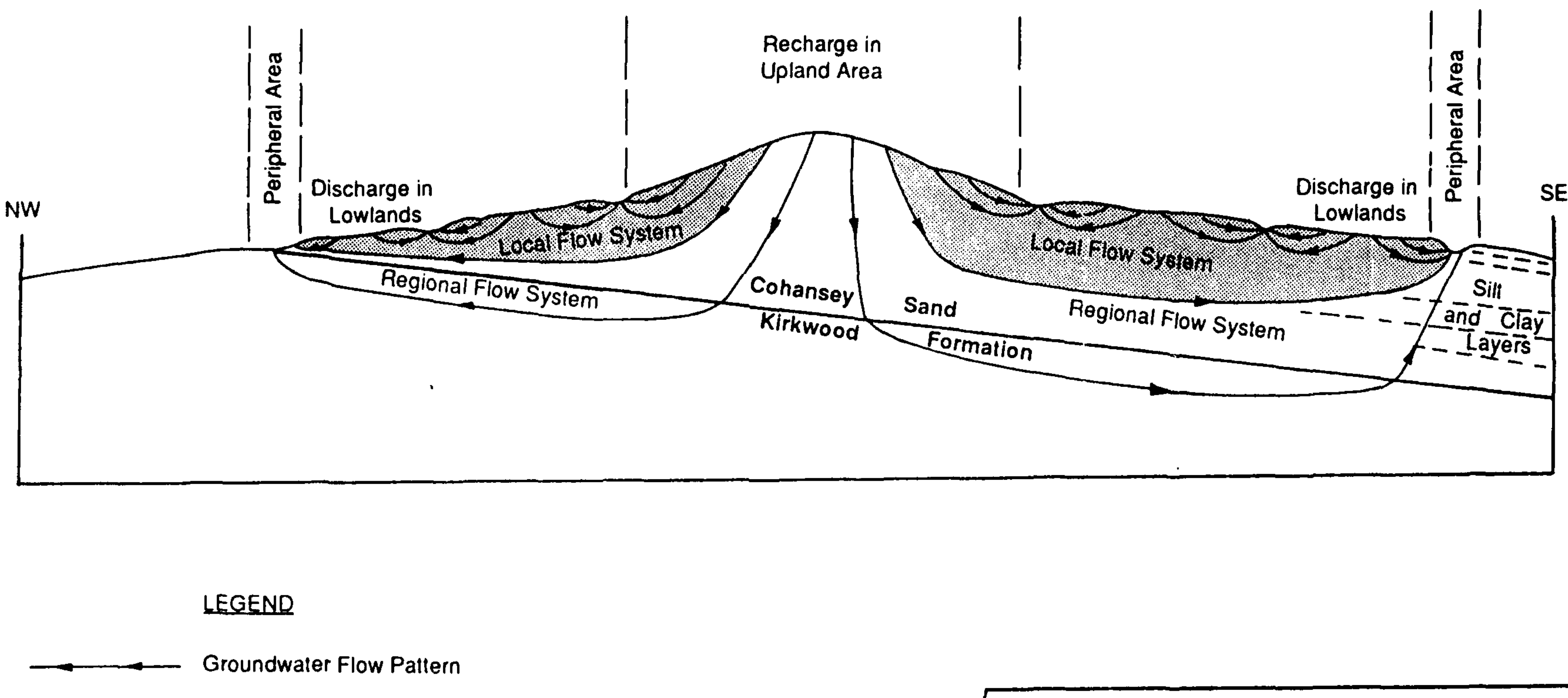

Source: Rhodehamel, 1970.

FIGURE 3-12

GROUNDWATER FLOW SCHEMATIC, PINELANDS REGION

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Table 3-9
Summary of Groundwater Analytical Results at
Site 1: BOMARC Missile Site

Monitoring Well	^{239}Pu (pCi/L)[a] Round 1	^{239}Pu (pCi/L)[a] Round 2	^{239}Pu (pCi/L)[b] Unfiltered	^{239}Pu (pCi/L)[b] Filtered
PU-1	<0.6	<0.6	----	----
PU-1A[c]	----	0.25 ± 0.09	----	----
PU-2	<0.6	<0.6	----	----
PU-3	0.8 ± 0.3	<0.6	<0.03	<0.05
PU-4	<0.6	<0.6	----	----
PU-5	<0.6	<0.6	----	----
PU-5[c]	<0.6	----	----	----
PU-6	<0.6	<0.6	----	----
PU-7	<0.6	<0.6	<0.03	<0.02
PU-7[c]	----	----	<0.1	<0.05
MW-49	----	----	<0.1	<0.05
Field Blank	<0.6	<0.6	----	----

Reanalysis of Samples PU-1 and PU-1A

PU-1	<0.6
PU-1 (QA-Dup)	<0.6
PU-1A	0.36 ± 0.09
PU-1A (QA-Dup)	0.33 ± 0.09

[a] Weston (1989). Detection limit was reported as 0.06 pCi/L where non-detects are reported. Weston's analytical protocol did not call for filtering.
[b] The Earth Technology Corporation, 1992
[c] Duplicate sample.

located outside the site boundaries have shown no contamination (USAFOEHL, 1988). Analyses of the soil samples collected during the drilling of PU-1 through PU-7 did not show any detectable levels of plutonium in the soil. Weston (1989) notes that, with one exception, plutonium was not detected in the second round of groundwater samples. Plutonium was detected in one sample, a duplicate sample of PU-1. Weston also notes that these water samples were not filtered. Plutonium is a low solubility metal which is highly sorptive and adheres to soil particles. The groundwater samples contained substantial amounts of suspended solids. It is not clear whether the plutonium detected at various times and in varying wells represents samples contaminated with the surface- contaminated soils, or if it reflects the actual presence of plutonium in the groundwater. It should be noted that because plutonium has low solubility and high sorption, it can be transported through groundwater with soil colloids. However, this type of transport is very erratic and difficult to predict. Relatively long-term pumping and sampling would be needed to actually detect its presence in a monitoring well.

Since 1985, the USGS and the NJDEPE have been studying the distribution of uranium, radium, and radon in groundwater in southern New Jersey (Szabo, USGS; NJDEPE Research Investigation, 1990; Zapecza and Szabo, 1989). Their studies include the Cohansey-Kirkwood aquifer in parts of five counties (Camden, Gloucester, Salem, Atlantic, and Cumberland). Eighty-two wells were sampled in the Cohansey-Kirkwood aquifer; 26 of the wells exceeded 5 pCi/L of combined radium. The gross alpha particle activity exceeded 5 pCi/L for 25 of the 26 wells with high combined radium. The highest level of contamination was 14 pCi/L.

Personnel from the U.S. Air Force Armstrong Laboratory resampled wells PU-3 and PU-6 in January 1992. Both filtered and unfiltered samples were collected and analyzed for gross alpha, gross beta, ^{239}Pu, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, and ^{226}Ra in an effort to determine which radionuclides were present in the samples, causing the observed elevated gross alpha activity. Sample data are provided as Table 3-10. ^{239}Pu was not detected in any of these samples. Results of this effort indicate that naturally-occurring uranium isotopes are present in the samples and are the cause of the elevated gross alpha activities observed.

Standard water supply parameters (i.e., inorganic species and others) have not been evaluated at the site. However, water quality data are available from past studies of regional conditions (see Table 3-8). The Pinelands groundwater quality is known to be acidic and to contain dissolved iron (similar to the surface waters). The pH ranges from 3.5 to 5.5 (Means *et al.*, 1981). This acidic nature may increase the solubility of plutonium. Total dissolved solids (TDS) range from 25 to 100 ppm, which is higher than TDS measured in surface water. This is believed to be due primarily to the enrichment of iron, aluminum, and other trace elements.

3.3.3.4 User Inventory

Large quantities of groundwater exist in the Cohansey-Kirkwood aquifer system. The resource is relatively undeveloped in the interior of the coastal plain, but is heavily utilized near the coast in the Atlantic City region.

Table 3-10
Results of BOMARC Monitoring Well Samples
(Sampling Conducted by Armstrong Laboratory, January 22, 1992)

Sample No.	Lab No.	Description	Gross Alpha	Gross Beta	Pu-239	Th-232	U-234	U-235	U-238	Ra-226
BK920001	19200131	Blank-unfiltered	1.1 ± 0.5	< 0.09	DNT	DNT	DNT	DNT	DNT	DNT
BK920002	19200132	Blank-filtered	< 0.06	3.1 ± 1.8	DNT	DNT	DNT	DNT	DNT	DNT
ON920003	19200133	Filter-blank	0.07 ± .05	< 0.56	DNT	DNT	DNT	DNT	DNT	DNT
GN920004	19200134	PU-3, Filtered	1.3 ± 0.6	< 3.3	DNT	DNT	DNT	DNT	DNT	DNT
GN920005	19200135	PU-3, Unfiltered	13.2 ± 2.9	2.2 ± 1.7	< 1.7	1.8 ± 1.1	32 ± 15	23 ± 11	26 ± 12	0.43 ± 0.45
ON920006	19200136	PU-3, Filtered	2.6 ± 0.5	2.7 ± 0.5	DNT	DNT	DNT	DNT	DNT	DNT
GN920007	19200137	PU-3, Unfiltered*	22.2 ± 4.1	2.7 ± 1.8	< 8.7	1.6 ± 1.1	18 ± 8	4.5 ± 3.1	12 ± 6	0.96 ± 0.69
GN920008	19200138	PU-3, Filtered*	2.9 ± 0.8	1.8 ± 1.7	DNT	DNT	DNT	DNT	DNT	DNT
GN920009	19200139	PU-6, Unfiltered	57.5 ± 8.3	8.3 ± 2.1	< 0.9	3.0 ± 1.5	44 ± 37	22 ± 33	22 ± 22	0.31 ± 0.48
GN920010	19200140	PU-6, Filtered	2.5 ± 1.1	2.6 ± 1.7	< 0.66	< 4.4	0.9 ± 0.4	< 0.17	< 0.16	< 0.13
ON920011	19200141	PU-6, Filtered	3.1 ± 0.5	2.3 ± 0.4	DNT	DNT	DNT	DNT	DNT	DNT
ON920012	19200142	PU-3, Filtered*	3.2 ± 0.5	2.4 ± 0.4	DNT	DNT	DNT	DNT	DNT	DNT

All results are in units of pCi/l.
* = Duplicate
DNT = Did not test.
Note: The instrument used for the gross alpha determinations is normally used for determining gross alpha in drinking water. These samples had a much higher suspended solids content; therefore, the apparent discrepancy between gross alpha and the uraniums is due to the alpha self-absorption on the gross alpha planchettes.

The BOMARC Missile Site is located within the area supplied by the Lakehurst Naval Air and Engineering Center (NAEC) Water System. A few other private, industrial, and agricultural groundwater users exist within the region (Battelle Columbus Division, 1988). The USAFOEHL (1988) study identified several private residence wells within one to three miles of the site.

3.4 Meteorology and Air Quality

This section describes the meteorology and existing air quality of the region. The air quality ROI is described. In terms of meteorology, both climatic conditions (temperature, precipitation, etc.), and those parameters affecting dispersion of pollutants, such as wind speed, direction, atmospheric stability, and mixing heights, will be characterized. Data used to describe the climatic and meteorological conditions were obtained from meteorological monitoring stations at both McGuire AFB and Lakehurst NAEC. These sites are located approximately nine miles west and six miles east of the BOMARC Missile Site, respectively, and are expected to exhibit conditions very similar to those of the site. The air quality of the region is somewhat more difficult to characterize due to limited available local air quality monitoring data.

3.4.1 Region of Influence

The air quality ROI includes (1) those areas directly impacted by the implementation of the alternatives by program-related construction activities; and (2) those areas in which the air quality may be affected indirectly (i.e. secondary impacts) through the implementation of the alternatives, i.e., by program-induced transportation impacts to air quality (such as traffic increases, or increased vehicle miles due to rerouting requirements or long-range transport to waste disposal sites). These ROIs were qualitatively addressed.

3.4.2 Meteorology

Meteorological/climatological data for the area are provided in Volume 3, Appendix 3-3. In Volume 3, Annex A of Appendix 3-3 contains regional climatic data (Table A-1), and seasonal and annual wind speed and directional distributions (Tables A-2 and A-3). The following sections describe some of the more salient information contained therein.

3.4.2.1 Temperature

The area has a generally moderate climate. Average annual temperatures are about 54°F, with July being the hottest month (average 76°F), and January the coolest (average 31°F) month. Annual average minimum and maximum temperatures for the period of record are 43°F and 63°F, respectively. Extreme temperatures of -13°F to 102°F have been recorded. The average number of frost-free days per year is about 265. The first killing frost usually arrives in this area at the end of October, and the last killing frost typically occurs during the last week of April.

3.4.2.2 Precipitation

Meteorological records for McGuire AFB and Lakehurst NAEC indicate that the mean annual precipitation is about 43 to 44 inches, and is fairly well distributed throughout the year.

Monthly maxima and minima over this same period range from less than 0.05 inches to 9.6 inches. The maximum precipitation in a 24-hour period was 9.6 inches, recorded at McGuire AFB during the month of August. Mean annual snowfall is 23 to 24 inches. The maximum monthly snowfall of 35 inches and the maximum 24-hour snowfall of 20 inches were recorded at Lakehurst during the month of March. Precipitation, in some form, occurs on the average about 115 days each year.

3.4.2.3 Winds

On an annual basis, prevailing winds are generally from the west to northwest, with a predominance of winds from the west. This strong westerly component is especially prevalent at Lakehurst, where winds are from the west almost 20 percent of the time. This direction is also associated with the strongest relative wind speeds (seven to nine knots). Average annual wind speeds are about six knots at both locations. On a seasonal basis, strongest wind speeds are experienced during the winter and spring months (about seven knots, average of all directions), and slowest wind speeds (about five to six knots, average of all directions) occur during summer and fall. During the winter, the predominant wind regime is from the west to west-northwest (40 to 50 percent), with high wind speeds (9 to 10 knots) associated with those directions. During the spring, these peak directions are still very evident; however, a southerly secondary maximum begins to take hold. In the summer, wind speeds decrease rather dramatically at both locations. At Lakehurst, the directional pattern in summary is very similar to that experienced during the spring; however, at McGuire AFB, the west to northwest maximum is observed in winter and in spring. In the summer, a dominant south to southwest wind flow with low speeds (about 3.5 to 4 knots) is experienced. The flow pattern during the fall months at both locations is similar to that of the spring, but the wind speeds are not as strong.

3.4.2.4 Humidity

The average relative humidity in the region ranges from 84 percent during the early morning hours (0400 Local Standard Time (LST)) to 56 percent during the afternoon (1300 LST).

3.4.2.5 Severe Weather

Severe weather in the area may take the form of hurricanes, tropical storms, severe thunderstorms, severe winter storms, and tornadoes.

Monthly and annual frequencies of thunderstorms are provided in Volume 3, Appendix 3-3 (Table A-1). The area experiences about 28 thunderstorms during an average year, with the majority occurring in the months of May through August. The percentage of these storms that may be considered severe is not evident from the information available.

Data regarding occurrence of hurricanes and/or tropical storms are available for McGuire AFB for the period of 1900 to 1986. During that period, there were five hurricanes and nine tropical storms within 60 nautical miles of the monitoring station. Within 120 nautical miles, there have been 12 hurricanes and 22 tropical storms. The number of hurricanes and tropical storms increases to 41 and 69, respectively, within a distance of 240 nautical miles (Air Weather Service, 1988).

The incidence of tornadoes in the State of New Jersey is rather low. Over a period of 20 years (1956 to 1975), the State has averaged two tornadoes per year. Information on the severity of these storms is not available; however, no deaths have been attributed to tornado activity (Ruffner and Bair, 1977).

High wind speeds may be a product of any of the above-mentioned storm types, as well as high pressure. The maximum instantaneous wind gust measured in the area is 76 knots. Wind gusts greater than 49 knots have been measured during each month; however, sustained wind speeds (hourly average) greater than 21 knots occur less than one percent of the time.

3.4.2.6 Atmospheric Dispersive Potential

Atmospheric dispersive potential is a function of wind speed, atmospheric stability, and the depth of the mixing layer (that depth of atmosphere through which pollutants may be effectively mixed). Dispersion may be considered on a long-term basis, such as annual or seasonal, or short-term, such as hourly or monthly.

Long-Term Average Meteorological Conditions. As mentioned above, dispersive potential is a function of wind speed, atmospheric stability, and depth of the mixing layer. Summaries of annual and seasonal wind speed and direction frequencies are provided in Volume 3, Appendix 3-3 (Table A-2 and Table A-3) and discussed in Section 3.4.2.3. This section will, therefore, focus on atmospheric stability and depth of the mixing layer.

Atmospheric stability can be discussed in terms of unstable, neutral, or stable conditions. Unstable conditions, wherein atmospheric temperature decreases rapidly with height, allow vertical dispersion of pollutants, yielding well-mixed atmospheres and strong dispersive potential. However, strong upward momentum may be accompanied by strong downdrafts, which give rise to local pockets of more intense pollutant concentrations. Neutral conditions, in which the temperature does not increase rapidly with height, also promote good atmospheric mixing. This does not occur as rapidly as the unstable case, and is not as conducive to strong downdrafts. Stable conditions are the result of either a slight temperature decrease with height, no temperature differential, or in the extreme case, a temperature increase with height. Stable conditions suppress vertical mixing of pollutants and tend to trap pollutants within the lower atmosphere.

The percentage frequency of each of these stability categories is provided in Table 3-11. On an annual basis, the region is expected to exhibit unstable conditions about 21 percent, neutral about 47 percent, and stable about 32 percent of the time. During the year, stable conditions occur most often during the winter at Lakehurst and during the fall at McGuire. Unstable conditions occur most often during the summer months at both locations.

Mixing heights for the area range from a low of about 650 meters during summer mornings, to more than 1500 meters during the spring and the summer afternoons. The average wind speed throughout the mixing layer is also at a minimum, five meters per second (m per s), during summer mornings and can be as high as 8.5 m per s during the winter (Holzworth, 1972).

Table 3-11
Annual and Seasonal Frequency of Atmospheric Stability Categories at Regional Sites

	Unstable	Neutral	Stable
		McGuire AFB	
Winter	7.2	57.4	35.4
Spring	18.6	50.1	31.3
Summer	33.5	30.0	36.5
Fall	19.2	38.2	42.6
Annual	19.7	43.9	36.4
		Lakehurst NAEC	
Winter	7.6	60.2	32.2
Spring	24.6	52.0	23.4
Summer	41.2	34.2	24.6
Fall	18.0	51.8	30.2
Annual	22.9	49.5	27.6

Source: Extracted from National Climatic Data Center data files.

Period of Record: McGuire AFB, 1/55 to 12/70.
Lakehurst NAEC, 1/76 to 12/77.

Worst-Case Short-Term Atmospheric Dispersion Conditions. Worst-case dispersion conditions are not easily quantified, because they vary according to the pollutant source. For instance, stable conditions, a low mixing height, and minimal wind speed might represent the worst-case dispersion conditions for pollutants emanating from nonbuoyant or slightly buoyant sources; however, high wind speeds might be more effective in contributing to the atmospheric loading of fugitive dust from soil erosion or agricultural activities. For the most part, limited dispersion conditions are described by a combination of low wind speeds, a shallow mixing layer, and stable atmospheric conditions.

3.4.3 Air Quality

Air quality is a function of the atmospheric pollutant loading and the ability of the atmosphere to disperse those pollutants. Atmospheric dispersive potential has been discussed above (Section 3.4.2.6). This section describes pollutant attainment status, ambient pollutant levels within the vicinity of the BOMARC Missile Site, and local and regional air pollutant sources.

3.4.3.1 Pollutant Attainment Status

NJDEPE routinely measures levels of priority pollutants, such as particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, lead, and ozone, at various locations throughout the state. Based on these measurements, areas are classified as attainment or nonattainment of the national or state Ambient Air Quality Standards (AAQS). Standards for priority pollutants are designated as primary, to protect public health, and secondary, to protect public welfare. These standards, as designated by the Federal CAA and its amendments, and the NJDEPE, are listed in Volume 3, Appendix 3-3, Table A-4.

The entire state has been classified as attainment of the standards for sulfur dioxide and nitrogen dioxide, but nonattainment of the standards for ozone. Portions of the state are classified as nonattainment of the standards for carbon monoxide and particulate matter less than or equal to 10 μm in diameter (PM_{10}). The area around the BOMARC Missile Site has been classified as attainment of all standards except ozone, for which both the primary and secondary standards are exceeded.

In terms of the CAA "Prevention of Significant Deterioration" (PSD) classification, the area is classified as Class II. This classification allows for a moderate increase in levels of particulate matter and sulfur dioxide from the baseline year of 1977. The only nearby Class I area (areas in which only very limited increases in particulate matter and sulfur dioxide will be allowed) is the Brigantine National Wildlife Refuge, which is about 45 miles to the south and is not expected to be impacted.

3.4.3.2 Ambient Pollutant Levels

As discussed previously, the NJDEPE routinely measures levels of priority pollutants at various locations throughout the state. For the most part, these monitoring sites are strategically located in areas expected to exhibit higher regional levels of pollutants, such as highly populated urban or industrial zones. As mentioned previously, the entire state is designated as nonattainment for ozone. Within the immediate vicinity of the BOMARC Missile Site, ozone is monitored at sites within McGuire AFB and Colliers Mills. At these sites, exceedance of the primary standard for ozone has often occurred. The most recent available data (1988) indicate that the primary standard has been exceeded 13 times, with the highest reading (0.197 ppm) well over the standard of 0.12 ppm that is established to protect human health. Table 3-12 provides additional information regarding regional ozone levels. Ambient particulate radioactivity content is discussed in Section 3.9.4.

Data regarding ambient concentrations of other criteria pollutants, such as volatiles, trace metals, acidic compounds, or other toxic air pollutants, are not available, but none of these are expected to be a particular problem in this rather rural setting. Ambient particulate radioactivity content is discussed in Section 3.9.5.

Table 3-12
Ambient Ozone Data for Regional Sites

	Daily Maximum One-Hour Average		Number of Days with Hourly Average Exceeding 0.12 ppm	Number of Hours Exceeding 0.08 ppm
	Highest	2nd Highest		
<u>1988</u>				
McGuire AFB[a]	0.197	0.182	13	302
<u>1987</u>				
McGuire AFB[a]	0.154	0.144	5	190
<u>1986</u>				
McGuire AFB	0.151	0.132	4	122
Colliers Mill[b]	0.159	0.142	4	152

Source: Extracted from New Jersey Department of Environmental Protection, 1987a, 1988a, 1989a.

[a]Data not available for the months of January, February, and December.
[b]Data not available for the months of January through March. and November through December.

3.4.3.3 Local and Regional Air Pollutant Sources

For purposes of air quality planning, the BOMARC Missile Site is located in the New Jersey Intrastate Air Quality Control Region (AQCR), shown in Figure 3-13. Within the local area, agricultural activities, light industry, military operations, and transportation contribute to the atmospheric pollutant loading. In addition, the region is often affected by the transport of pollutants from major metropolitan areas. Regional sources of air pollutants include point sources such as fossil-fuel burning power plants and industrial operations, area sources such as forest fires, agricultural activities, and unpaved roads, and line sources -- primarily from vehicular and air traffic. A majority of local air quality degradation can be traced to surrounding urban areas (including Philadelphia, Camden, Burlington, Wilmington, and Trenton).

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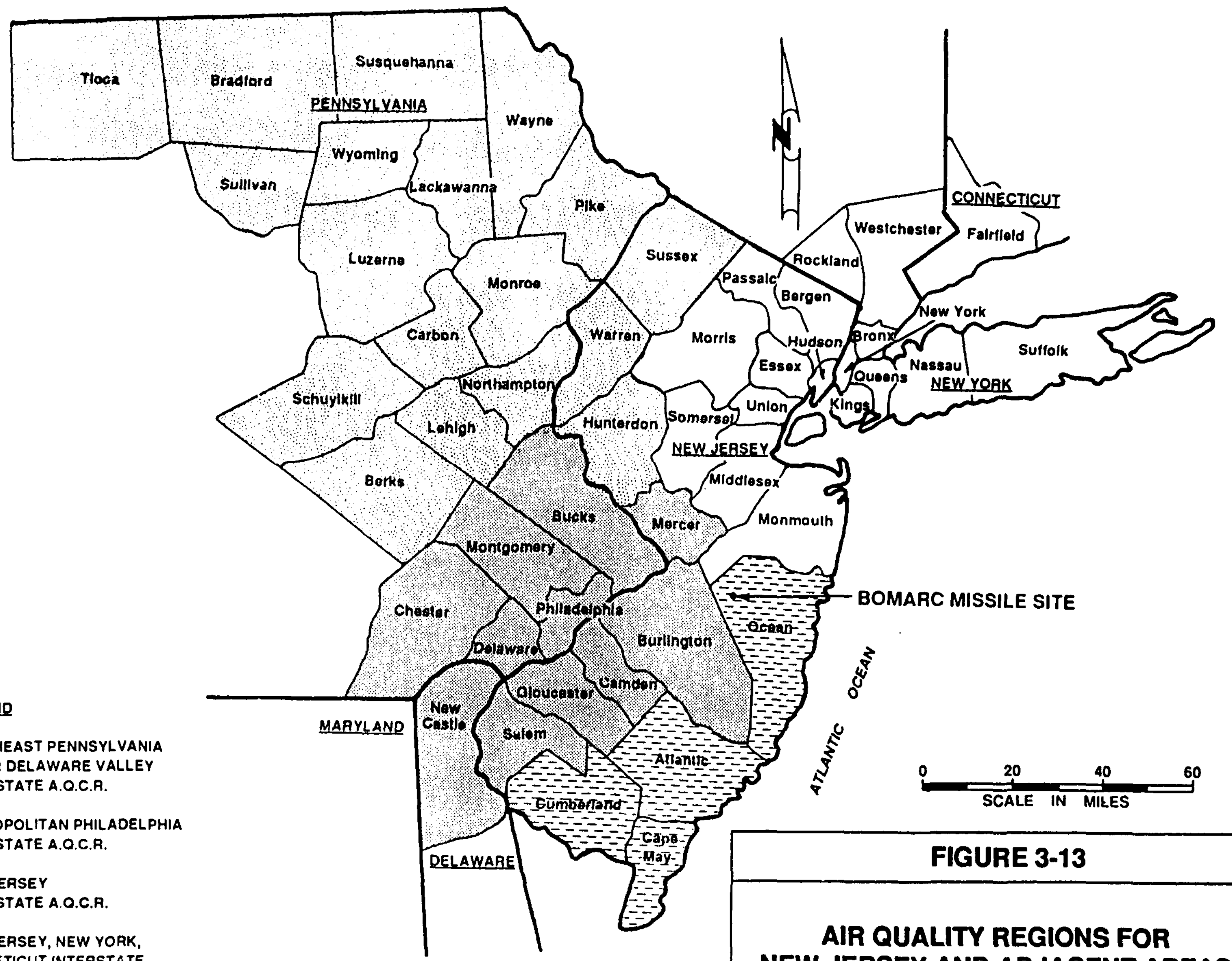

LEGEND

- NORTHEAST PENNSYLVANIA UPPER DELAWARE VALLEY INTERSTATE A.Q.C.R.
- METROPOLITAN PHILADELPHIA INTERSTATE A.Q.C.R.
- NEW JERSEY INTRASTATE A.Q.C.R.
- NEW JERSEY, NEW YORK, CONNETICUT INTERSTATE A.Q.C.R.

FIGURE 3-13

AIR QUALITY REGIONS FOR NEW JERSEY AND ADJACENT AREAS

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As mentioned previously, ozone is the only known major pollutant of concern in the local area. Ozone, or photochemical smog, is created through a series of chemical reactions in the presence of sunlight. Volatile organic substances (VOS) from gasoline, motor vehicle exhaust, evaporative losses from hydrocarbon storage facilities, and industrial, commercial and consumer activities, together with oxides of nitrogen, found in exhausts of motor vehicles and electrical generating stations, are recognized as precursors to the formation of ozone. The ozone problem is recognized as a regional problem in that its formation and damaging effects often occur hundreds of miles downwind of the source. Sources within Pennsylvania, Maryland, and Delaware contribute significantly to ozone levels in the region. In the Greater Philadelphia Area, sources within New Jersey contribute less than one-third of the ozone-promoting emissions. Due to prevailing meteorological conditions, this area receives the greatest impact. Ambient levels peak during times of more intense sunlight, and follow a diurnal trend, with peak ozone levels occurring shortly after periods of intense traffic (New Jersey Department of Environmental Protection, 1983b).

The most recent available statewide emission inventory, based on 1980 data, indicates that the contribution of stationary sources are the most significant contributor to ambient levels of ozone precursors, exceeding that of mobile sources. Within the New Jersey Intrastate AQCR and bordering Metropolitan Philadelphia Interstate AQCR (a major source of pollutants transported to the area), VOS emissions are attributed to various source categories, as shown in Table 3-13. Motor vehicles are a significant contributor to ambient levels of nitrogen dioxide, carbon monoxide, particulate matter, and lead.

Table 3-13
Current and Projected VOS Emissions[a] in the Region

Source	Base Year 1980	Projected Baseline Attainment Year 1987	Percent (%) Change
New Jersey Intrastate AQCR			
Industrial	10	8	-20
Highway	48	21	-56
Other Sources[b]	60	55	-8
Regional Total	118	84	-29
Metropolitan Philadelphia Interstate AQCR			
Industrial	109	46	-58
Highway Vehicles	84	39	-54
Other Sources[b]	84	70	-17
Regional Total	277	155	-44

Source: Extracted from New Jersey Department of Environmental Protection, 1983b.

[a] Given in metric tons per day.
[b] Other sources include categories consisting of many small sources, such as off-highway vehicles, structural fires, degreasing operations, architectural painting, auto body shop painting, commercial and consumer solvent use, gasoline service stations, dry cleaning, asphalt paving, and a few other area sources. Natural sources of VOS, such as from vegetation, are not included.

The NJDEPE has embarked on a program to reduce emissions of ozone precursors in an attempt to meet standards for ozone throughout the state. According to the most recent State Implementation Plan (SIP), which outlines the proposed program for meeting compliance with AAQS, the State has achieved a 70 percent reduction in hydrocarbon emissions through its mandatory vehicular inspection and maintenance program. Such programs are also expected to contribute to the reduction of emission levels and maintenance of air quality standards for nitrogen dioxide, carbon monoxide, lead, and particulate matter. Ozone, however, is expected to continue to be a problem for some time (New Jersey Department of Environmental Protection, 1983b).

3.5 Biology

The baseline biological conditions at the BOMARC Missile Site are described in the following sections. The ROI is defined. The vegetation found on-site as well as the vegetation surrounding the site, affected by the site's ROI, are described. The faunal species inhabiting and potentially inhabiting the site's ROI are also listed and discussed. Federal and state threatened or endangered plant and animal species inhabiting or potentially inhabiting the site's ROI are also discussed.

3.5.1 Region of Influence

The ROI for biological resources is defined as the area or location where these resources can reasonably be expected to be directly or indirectly affected by the activities associated with the five alternatives for the BOMARC Missile Site. For biological resources, it is important to distinguish between areas and resources that may be subject to direct surface disturbance and other direct impacts from construction and operations activities, and areas where only indirect program impacts could occur. As a result of animal movement throughout normal daily or yearly ranges, burrowing and browsing vertebrates and invertebrates may transport significant quantities of inhaled or ingested contaminants into areas outside the immediate or primary ROI. Later the contaminated matter could be deposited (in scat or in the deceased organism) in areas adjacent to the ROI. Therefore, indirect impacts associated with contamination migration through biological pathways can potentially occur prior to and during program-induced development. The portion of the ROI that would be subject to direct impact includes the areas disturbed due to site work associated with the actions and alternatives program (areas onbase and nearby) as well as adjacent areas that may also be affected by factors such as noise and runoff. Also, as mentioned above, locations of indirect impact may include areas within the daily or yearly ranges of animals inhabiting the primary ROI. These ranges were more closely defined by examining the information within the data sources and from the field survey conducted on site.

3.5.2 Vegetation

The BOMARC Missile Site is located within the northwestern area of the Pinelands region (New Jersey Pine Barrens). The New Jersey Pine Barrens cover approximately 2,000 square miles (McCormick, 1970). The New Jersey Pine Barrens contain a unique ecological zone, primarily coniferous forest, which differs significantly from the surrounding deciduous forest climax vegetation more characteristic of the eastern United States. This ecological uniqueness has been maintained by a number of natural and cultural events. First, the soils within the Pinelands are composed largely of coarse sands and gravels of the Atlantic Coastal Plain, which allow for rapid infiltration of rainfall, thus setting up very dry surface conditions. Frequent fires result from the presence of fire-promoting vegetation. Second, prior to the early part of this century, the Pineland forests were clear-cut every 25 to 50 years (McCormick in Forman, 1979; McCormick, 1970). These factors prevent the typical deciduous forest climax community from becoming established in the Pinelands.

Two floristic complexes exist in the Pinelands, whose distinctive vegetative differences are a reflection of water table level. In the lowland floristic complex, the water table is located at or very near the surface. Marsh, swamp, and bog flora occur in these areas as a result. The water table is found at much greater depths (2 to 3 ft up to 70 ft) (McCormick, in Forman, 1979) in the upland floristic complex. Dry woods flora, primarily pine, pine-oak, or oak-pine forest types, occur in these areas.

3.5.2.1 Oak-Pine Forest Habitat

The BOMARC Missile Site and associated ROI are located in an upland zone. Oak-pine forest vegetation surrounds the site (Figure 3-14).

During June and July of 1989, ecological field work was conducted at the BOMARC Missile Site. Tables of data collected to characterize the oak-pine forested area are provided in the Annex to Volume 3, Appendix 3-4. These tables include a vascular plant inventory (Volume 3, Appendix 3-4, Table A-1), an inventory of trees present (Volume 3, Appendix 3-4, Table A-2), canopy species density information (Volume 3, Appendix 3-4, Table A-3), and ground species density data (Volume 3, Appendix 3-4, Table A-4).

The treeform species which compose the oak-pine forest type surrounding the site include pitch pine *(Pinus rigida)*, chestnut oak *(Quercus prinus)*, scrub or bear oak (when over 10 feet in height) *(Quercus ilicifolia)*, black oak *(Quercus velutina)*, blackjack oak *(Quercus marilandica)*, and post oak *(Quercus stellata)*. Pitch pine, the most commonly occurring tree species, accounted for approximately 50 percent of the individuals counted in the survey (Volume 3, Appendix 3-4, Tables A-2 and A-3). The next most commonly occurring tree species was chestnut oak at just over 25 percent of the total. Black oak, blackjack oak, scrub oak and post oak made up the balance of the trees inventoried. Although not included within the sampling units, sassafras was occasionally present in the oak-pine forest surrounding the site. In terms of tree species representation, approximately 50 percent are oaks. Tree density averaged over 500 trees per acre. Approximately 68 percent of the ground surrounding the site was covered by tree canopy. Of this total, about one-half the canopy cover was contributed by pitch pine. The oak species contributed the other half of this canopy (Volume 3, Appendix 3-4, Table A-3).

The understory of the oak-pine forest encompassing the site consisted of a moderately to extensively dense shrub zone. The shrub zone of the oak-pine forest surrounding the site consisted almost exclusively of species of two genera *(Vaccinium and Gaylussacia)* of the heath family *(Ericaceae)* and scrub oak *(Quercus ilicifolia)* (Volume 3, Appendix 3-4, Table A-4).

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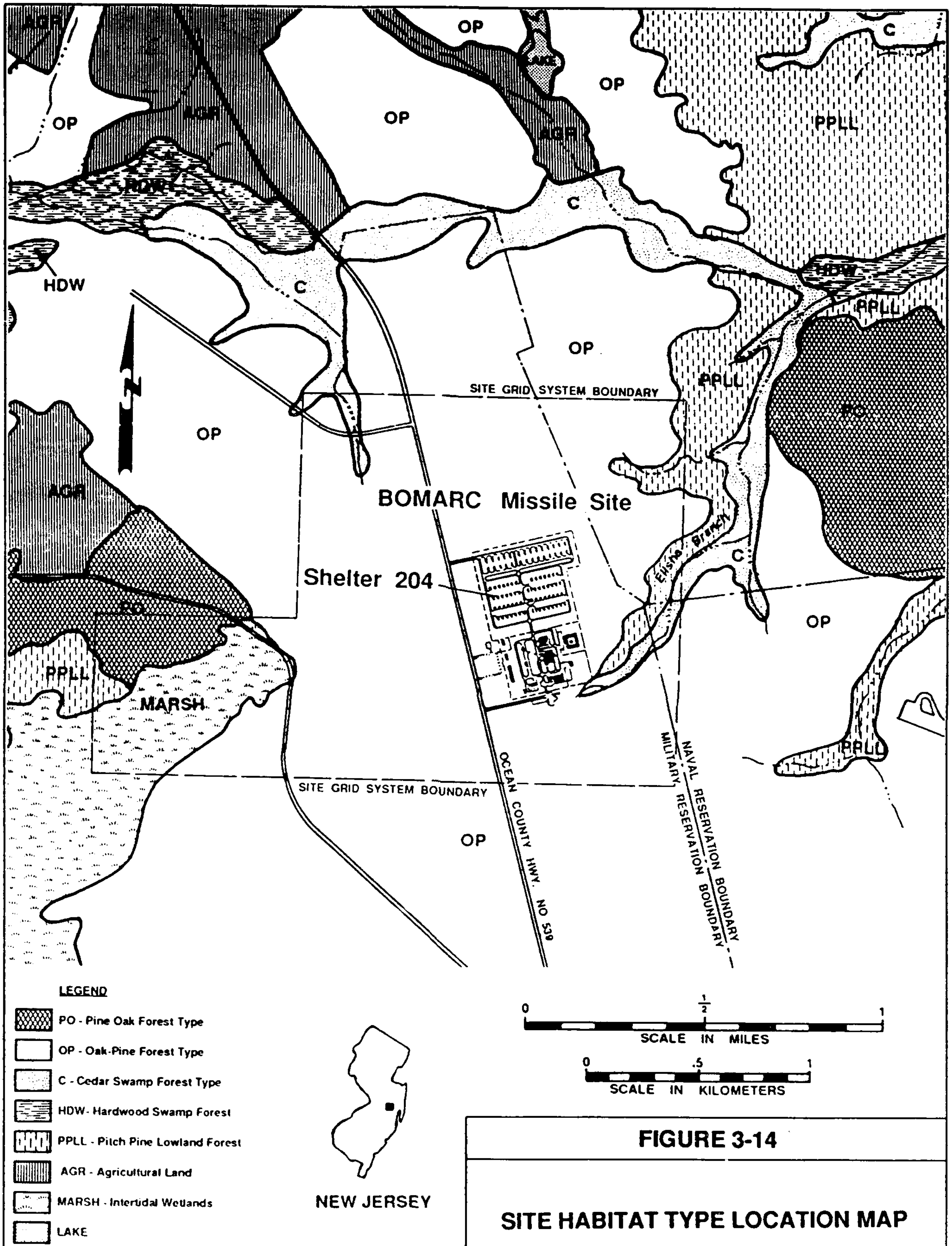

Source: McCormick & Jones, 1973.

FIGURE 3-14

SITE HABITAT TYPE LOCATION MAP

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Herbaceous zone vegetation species density was quite low compared to the shrub zone. Only one herbaceous species occurred in any significant abundance, the bracken fern *(Pteridium aquilinum)*. This species appeared in only one of the 30 1-m^2 sample quadrants in the one to five percent cover class category (Volume 3, Appendix 3-4, Table A-4).

3.5.2.2 Old Field Habitat

The unpaved areas surrounding the missile shelters and support buildings at the BOMARC Missile Site support an early phase old field vegetative habitat. Old field habitats occur as a result of secondary vegetative succession of abandoned cropland or other cleared habitats. Because the grounds on the site are presently mowed twice per year, old field succession is maintained in an early phase. In contrast to the oak-pine forest vegetative habitat which surrounds the site, the old field habitat lacks shrub zone and treeform vegetation. The only trees and shrubs present are represented by widely scattered and isolated individuals. The old field habitat at the BOMARC Missile Site consists almost exclusively of herbaceous vegetation (Volume 3, Appendix 3-4, Table A-5).

The most dominant herbaceous plant species present, particularly near missile Shelter 204 and the associated drainage swale, include members of the grass family (Gramineae or Poaceae). In terms of plant density, the most commonly occurring species include chess grass *(Bromus secalinus)*, Virginia wild rye *(Elymus virginicus)*, a crabgrass species (*Digitania*, sp.) and a rye grass species (*Lolium* sp.) (Volume 3, Appendix 3-4, Table A-6). Other common grass species which were relatively abundant on the site include Japanese bromegrass *(Bromus japonicus)*, purpletop grass *(Trioda flava)*, red fescue *(Festuca rubra)*, and two panic grass species *(Panicum polyanthes* and *P. implicatum)*. Other herbaceous plant species (not grass family members) which were relatively abundant at the site include meadow buttercup *(Ranunculus acris)*, bushy aster *(Aster dumosus)*, rabbitfoot clover *(Trifolium arvense)*, wild garlic *(Allium sativum)*, and yarrow *(Achillea millefolium)*.

3.5.3 Fauna Species Habitats and Distributions

A complete field reconnaissance and systematic faunal population survey were not attempted due to time and budgetary constraints. Therefore, the majority of the information contained within this document concerning animal ranges, species presence, habitat preference, and population status is taken from previously published sources. The sources for the following information include Penkala *et al.* (1980), Forman (1979), Weiss and West (1924), and McCormick (1970).

3.5.3.1 Mammals

Mammals observed during the ecological field work phase of the BOMARC Missile Site baseline characterization included white-tailed deer *(Odocoileus virginianus)*, woodchuck *(Marmota monax)*, eastern cottontail rabbit *(Sylvilagus floridanus)*, white-footed mouse *(Peromyscus leucopus)*, and striped skunk (*Mephitis mephitis*). White-tailed deer is the most conspicuous mammal within the ROI. Evidence of this species (sightings, tracks, bones, and roadkills) was observed throughout the site ROI and its immediate vicinity. Table 3-14 lists habitat and

Table 3-14
Mammals and Game Birds Potentially Inhabiting the BOMARC Missile Site Biological ROI

Common Name	Scientific Name	Habitat	Population Status	Game Code Status
Opossum	Didelphis marsupialis	OP, OF	C	Hunted
Raccoon	Procyon lotor	OP, OF	C	Hunted, Trapped
Long tailed weasel	Mustela frenata	OP, OF	C	Trapped
Mink	Mustela vison	OP, OF	C	Trapped
Striped skunk	Mephitis mephitis	OP, OF	C	Trapped
Red fox	Vulpes fulva	OP, OF	C	Hunted, Trapped
Grey fox	Urocyon cinereoargenteus	OP, OF	C	Hunted, Trapped
Black bear	Ursus americanus	OP, OF	E	Protected
Bob cat	Lynx rufus	OP, OF	E	Protected
Eastern coyote	Canus latrans	OP	P	Protected
Red squirrel	Tamiasciurus hudsonicus	OP	A	Protected
Woodchuck	Marmota monax	OF	UC	Hunted
Eastern cottontail	Sylvilagus floridanus	OP, OF	C	Hunted
White tail deer	Odocoileus virginianus	OP, OF	C	Hunted
Masked shrew	Sorex cinereus	OP, OF	C	Nongame Mammal
Short-tailed shrew	Blarina brevicauda	OP, OF	UC	Nongame Mammal
Least shrew	Cryptotis parva	OF	UD	Nongame Mammal
Eastern mole	Scalopus aquaticus	OF	C	Nongame Mammal
Little brown bat	Myotis lucifugs	OP, OF	UD	Nongame Mammal
Eastern pipistrel	Pipistrellus subflavus	OP, OF	UD	Nongame Mammal
Big brown bat	Eptesicus fuscus	OP, OF	UD	Nongame Mammal
Eastern chipmunk	Tamias striatus	OP, OF	C	Nongame Mammal
Flying squirrel	Glaucomys volans	OP	C	Nongame Mammal
White-footed mouse	Peromyscus leucopus	OP, OF	C	Nongame Mammal
Red-backed vole	Clethrionomys gapperi	OP	C	Nongame Mammal
Pine vole	Pitymys pinetorum	OP	C	Nongame Mammal
Norway rat	Rattus norvegicus	OF	C	Nongame Mammal
House mouse	Mus musculus	OF	C	Nongame Mammal
Meadow jumping mouse	Zapus hudsonius	OF	UD	Nongame Mammal
Ruffed grouse	Bonasa umbellus	OP	C	Hunted
Bob white	Colinus virginianus	OP	A	Hunted
Wild turkey	Meleagris gallopavo	OP	R	Protected

Source: Penkala, Hahn, and Sweger, 1980.

OP	=	Oak-Pine Forest	A	=	Abundant
OF	=	Old Field	P	=	Peripheral
C	=	Common	E	=	Extirpated
UC	=	Uncommon	R	=	Recently Reintroduced
UD	=	Undefined			

distribution data for mammals potentially inhabiting the project area. A table of game and fur-bearing mammals found in Ocean County appears in Volume 3, Appendix 3-4, Table A-7.

A list of small mammals found in Ocean County is provided in Volume 3, Table A-8 of Appendix 3-4. A list and range descriptions of mammals, which have been recorded as inhabiting the Pinelands region, is summarized in Volume 3, Appendix 3-4, Table A-9.

3.5.3.2 Birds

Birds observed during the ecological field work phase of the BOMARC Missile Site baseline characterization included turkey vultures *(Cathartes aura)*, barn swallows *(Hirundo rustica)*, common crows *(Corvus brachyrhynchos)*, catbirds *(Dumetella carolinensis)*, robins *(Turdus migratorius)*, eastern bluebirds *(Sialia sialis)*, rufous-sided towhee *(Pipilo erythrophthalmus)*, chipping sparrows *(Spizella passerina)*, mourning dove *(Zenaidura macroura)*, and a hawk species (*Buteo* sp.). The most common bird within the ROI was the barn swallow. Several active nests (including three nests in Shelter 204) were observed in the missile shelters at the BOMARC Missile Site. A list of the preferred habitats of some common Pineland breeding birds is given in Volume 3, Appendix 3-4, Table A-10.

The game birds of Ocean County are listed in Volume 3, Appendix 3-4, Table A-11 and game birds potentially inhabiting the BOMARC Missile Site are listed in Table 3-13. A species list and range descriptions of birds which have been recorded as inhabiting the Pinelands region, are given in Volume 3, Appendix 3-4, Table A-12.

3.5.3.3 Reptiles and Amphibians

Pinelands herpetofauna on a regional scale is fairly varied and diverse and are summarized in Volume 3, Appendix 3-4, Tables A-13 and A-14. However, in upland areas herpetofaunal populations are not considered numerous enough to be a significant food web contributor (McCormick, 1970). The only herpetofaunal representatives observed in or near the site ROI were a fowler's toad *(Bufo woodhousei fowleri)*, a northern fence lizard *(Sceloporous undulatus hyacinthus)*, and a black snake *(Coluber constrictor constrictor* or *Elaphe obsoleta obsoleta)*.

3.5.3.4 Fish

The BOMARC Missile Site is located in an upland area devoid of suitable habitat for fish (ponded water or perennial streams). No fish were observed in the intermediate section of the Elisha Branch which is located just south of the site. The closest potential fish habitat near the BOMARC Missile Site is a cedar swamp area located approximately 0.20 miles east of the site's southeast boundary. A list of fish which inhabit the Pinelands region is located in Volume 3, Appendix 3-4, Table A-15.

3.5.3.5 Invertebrates

A comprehensive survey of insect species (Weiss and West, 1924) in a dry woodlands area of the Pinelands was conducted just seven miles east of the BOMARC Missile Site at Lakehurst in

1924. The 381 insect species identified in the survey are listed in Volume 3, Appendix 3-4, Table A-16. However, relatively few insects have been seen at the BOMARC Missile Site.

3.5.4 Threatened and Endangered Species

A number of ecologically sensitive plant and animal species may potentially inhabit the BOMARC Missile Site ROI. Several species known to inhabit the area are listed as threatened or endangered by the U.S. Fish and Wildlife Service or the NJDEPE, or are species of concern to the New Jersey Pinelands Commission. Only those plant and animal species of concern that are listed by the above agencies, and are potentially affected by the proposed project, are treated in detail in Volume 3, Appendix 3-4.

A table of rare, threatened, and endangered plant and animal species that have been recorded in the general vicinity of the BOMARC Missile Site is provided in Volume 3, Appendix 3-4, Table 2-2. Table 2-3 of Volume 3, Appendix 3-4 lists rare, threatened, and endangered species recorded within one mile of the site.

Two species of threatened plants have been identified at the BOMARC Missile Site. Three populations of Greene's rush (*Juncus greenei*) have been observed on the site. This is a rare and threatened plant. A large population of sickle-leaved chrysopsis (*Chrysopsis falcata*) has also been observed at the site. This plant is considered locally threatened or endangered in the New Jersey Pinelands.

3.5.5 Biological Transmission of Plutonium

Current research indicates that plutonium released into the environment is not concentrated by terrestrial plants (Hakonson *et al.*, 1981; McLeod *et al.*, 1981). In fact, soil-plant uptake, measured as a percentage of plant-plutonium concentration to soil concentration (i.e., the concentration factor), has been found to be extremely low based on a number of greenhouse experiments (Bennett, 1976). Soil-plant concentration factors ranged from 3×10^{-2} to 4×10^{-8} for plutonium. Americium concentration factors were also found to be very low. The results of research performed by Oak Ridge National Laboratory (Baes *et al.*, 1984) placed the soil to plant concentration factor at 0.0055 for americium.

The magnitude of plant to animal concentration of ^{239}Pu from ingestion of plants grown in plutonium-contaminated soils appears to be very low or negligible (Bennett, 1976). Romney *et al.* (1970) found that less than 0.003 percent of orally administered plutonium was absorbed across the gastrointestinal tract of rats. Data from studies at other plutonium-contaminated sites, including analysis of soil, plants, and animals inhabiting the Los Alamos and Trinity ecosystems, suggest extremely low plant and animal bioassimilation of plutonium from contaminated soil after 30 years of exposure. Mass inventory ratios, percentage of biota/plutonium mass to soil/plutonium mass concentration, from Mortandad Canyon at Los Alamos yielded plutonium inventory ratios of between 4.1×10^{-5} (for grasses and forbs, respectively) and 1.5×10^{-9} for rodents (Hakonson and Nyham, 1980).

3.5.6 Organism Contamination Analysis

An attempt was made to collect invertebrates, larvae or pupae, from the soils of the six soil test pits (Section 3.2.7.3) for analysis of plutonium and americium. However, the soils of the Pinelands do not support significant populations of invertebrates. Despite excavation of six soil test pits, the total number of specimens collected was of insufficient mass for a single analysis.

Numerous attempts were also conducted to collect small mammals. Traps were set for a total of 15 days (June and July 1989) in order to capture specimens for whole body analysis of plutonium and americium. One white-footed mouse was captured and subsequently analyzed by Teledyne Isotopes, Inc. The analytical results from alpha spectrometry indicated that the ^{239}Pu and ^{241}Am levels of the mouse were below the instrument detection limits (^{239}Pu - 1.0×10^{-3} pCi per g, ^{241}Am - 3.0×10^{-2} pCi per g).

3.6 Land Use

A five-mile radius was used to determine the ROI for land use. It includes land in the political jurisdictions proximate to the site. This section describes land uses within the five-mile radius of the BOMARC Missile Site.

3.6.1 Existing Land Uses

A number of federal facilities occupy land immediately surrounding the site within the five-mile radius ROI. Federal facilities include Fort Dix, McGuire AFB, and Lakehurst NAEC. Federal and state facilities are shown in Figure 3-15. In addition to these federal facilities, adjacent lands contain a New Jersey National Guard facility, the Colliers Mills State Fish and Wildlife Management Area, as well as limited areas of agricultural, commercial, and residential uses. The U.S. Department of Agriculture Soil Conservation Service has designated several soil types as prime farmland (Facsimile from R. Taylor, U.S. Department of Agriculture Soil Conservation Service, February 21, 1992). Two occurrences of one of those soil types (Downer sandy loam, 2% to 5% grade) are located near the BOMARC Missile Site. A small area (approximately 1,200 feet by 800 feet) of this Downer sandy loam occurs approximately 0.25 miles east of the site (Figure 3-3). There is a second occurrence of the Downer sandy loam approximately 1 mile north-northwest of the site.

Current activities, proximity of employment centers, and housing on federal bases in the vicinity of the BOMARC Missile Site are discussed in the following sections.

3.6.1.1 Federal and State Properties

There three federal facilities located adjacent to the site. These are Fort Dix, McGuire AFB, and Lakehurst NAEC. None of these facilities has housing located within close proximity to the site. In all cases, housing on those military installations is located at least five miles from the BOMARC Missile Site.

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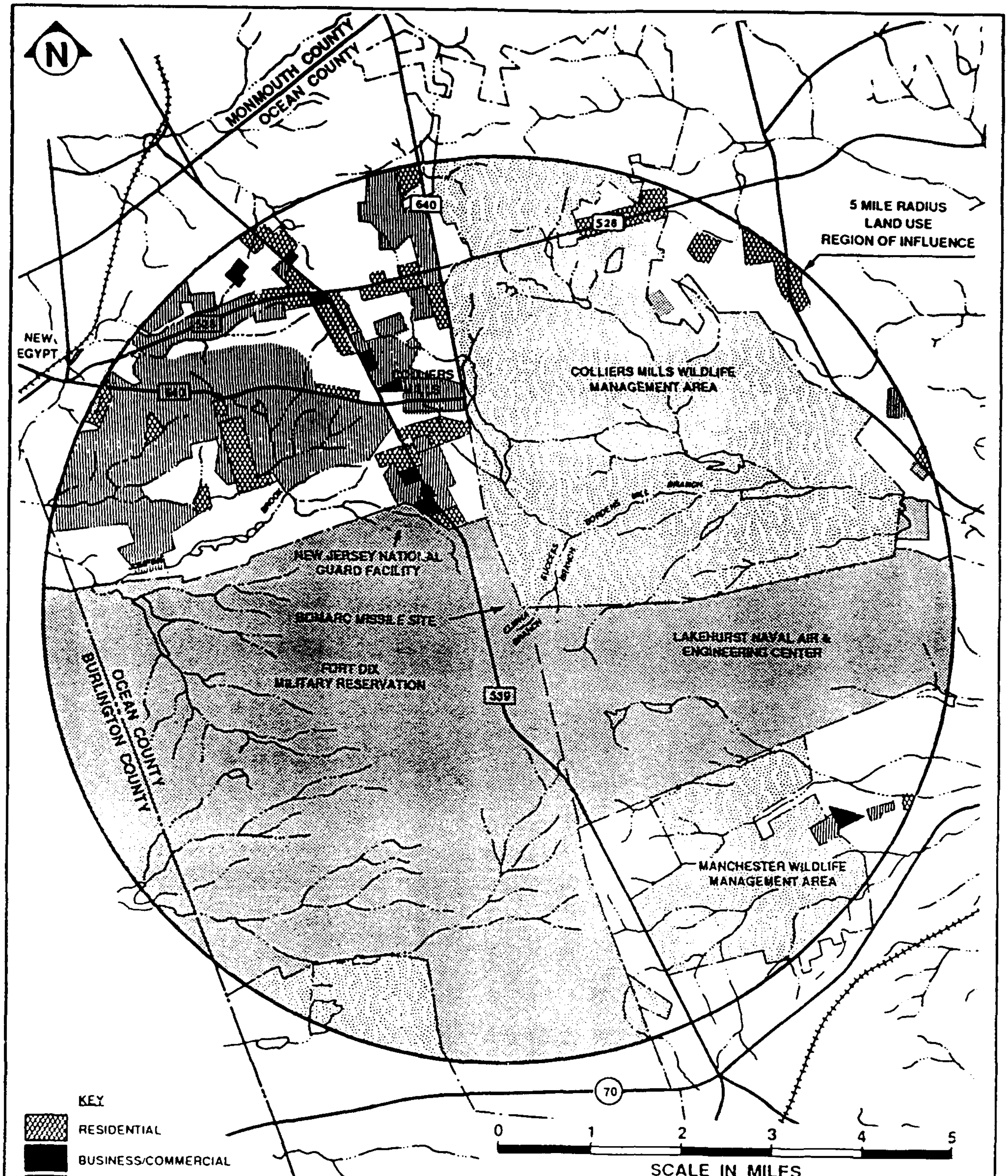

KEY

- RESIDENTIAL
- BUSINESS/COMMERCIAL
- PUBLIC/MILITARY
- PARKS/CONSERVATION
- AGRICULTURE
- WOODED/VACANT

Source: Ocean County Planning Board, 1987.

FIGURE 3-15

LAND USE WITHIN FIVE-MILE RADIUS OF BOMARC MISSILE SITE

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3.6.1.1.1 McGuire Air Force Base

The BOMARC Missile Site is located on land that McGuire AFB permitted from Fort Dix. Since the site was deactivated in 1972, the Air Force has continued to retain the site and provide overall maintenance and security. Presently there are no activities occurring on the 219-acre parcel. The remainder of McGuire AFB, some 3,536 acres, lies 11 miles to the west of the BOMARC Missile Site in Burlington County. This is beyond the five-mile radius used as the land use ROI.

3.6.1.1.2 Fort Dix

The BOMARC Missile Site is located at the eastern edge of Fort Dix and is surrounded on its northern, western, and southern boundaries by that installation. Fort Dix is one of the installations that has been recommended for closure by the Department of Defense (DoD) (Defense Base Closure and Realignment Commission Report to the President, 1991). Fort Dix extends westward through Ocean and Burlington Counties, covering a total area of nearly 32,000 acres. In the immediate vicinity of the BOMARC Missile Site, Fort Dix encompasses both sides of Route 539 for approximately three miles.

Fort Dix is presently a major training facility for the United States Army. Major portions of the eastern half of the base (where the accident site is located) contain marsh and bog lands. Permanent housing is not located in this area, although troops may reside in this area on a temporary basis during training exercises. The majority of permanent structures within the Fort Dix complex are located in Burlington County, beyond the five-mile radius land-use ROI.

3.6.1.1.3 Lakehurst NAEC

Lakehurst NAEC is located southeast of the BOMARC Missile Site. Encompassing 7,412 acres in Ocean County, Lakehurst NAEC is an active air and research command. The closest Lakehurst facilities to the BOMARC Missile Site are the runways, located in the western section of the installation. Residential structures and employment centers are located at the east end of the Base, more than five miles from the site, and outside the land use ROI.

3.6.1.1.4 New Jersey State National Guard Facility

The New Jersey State National Guard Facility, located approximately two miles northwest of the BOMARC Missile Site, employs 25 people on a full-time basis, and serves as a major distribution center for heavy equipment used in National Guard training programs. Approximately 100 to 200 individuals pass through the site during a weekend. The main access to the site occurs along Route 539; access is also available through Fort Dix via Range Road.

3.6.1.1.5 Colliers Mills Wildlife Management Area

The Colliers Mills Wildlife Management Area (shown in Figure 3-15), administered by the NJDEPE, Division of Fish, Game and Wildlife, is located northeast of the site, adjacent to both Fort Dix and Lakehurst NAEC.

The Management Area contains 12,368 acres and has a small number of staff residences (year-round) and seasonal cottages that are leased on an annual basis. Licensed hunting is permitted for all categories of game allowed in the state, including deer, birds, and small animals. Although the Management Area contains numerous natural cranberry bogs, cranberry harvesting is not permitted.

In the New Jersey Pinelands Comprehensive Management Plan or NJPCMP (New Jersey Pinelands Commission, 1980), the acquisition of additional preservation lands is a stated goal. The Colliers Mills Area has been designated as a preserve to be expanded. Presently, there are no formal negotiations for land acquisition.

3.6.1.2 Local Land Uses

The community of New Egypt is located, in part, within five miles of the BOMARC Missile Site in Plumsted Township. It is situated to the northwest of the BOMARC Missile Site (see Figure 3-15). New Egypt has some commercial development. However, this area has not experienced as much pressure for development as other communities in the region.

The surrounding township of Plumsted, located north of the BOMARC Missile Site, reflects the traditional rural development pattern of central New Jersey, which is based on agricultural use and scattered residential development in single-family structures on larger lots. Small pockets of service and commercial development supporting this local population are located along Routes 539 and 528.

Agricultural activity in Ocean County is centered directly north of Fort Dix and the BOMARC Missile Site in Plumsted Township and adjoining Jackson Township. Currently, more than 10,000 acres of Ocean County is involved in the production of vegetables, fruits, cranberries, blueberries, dairy products, field crops, ornamentals, and horses (Orange County Planning Board, 1988b). Remaining acreage in Plumsted Township is mostly wooded or vacant.

Adjacent land areas in neighboring Burlington and Monmouth Counties are comparable to Plumsted Township in land use type and development patterns. These counties lay beyond the five-mile radius land use ROI. The counties have a similar development history and pattern of agricultural and residential use.

The southern portion of Ocean County has experienced rapid development in the past few years. A large amount of this development has been in retirement communities, including single-family detached housing, multiplexes, condominiums, and congregate living structures. A number of support facilities have also been developed to serve this aging population. These include hospitals, nursing homes, and life care facilities. These developments are beyond the five-mile radius land use ROI.

3.6.2 Land Use Plans, Policies, and Controls

Development within the immediate area of the BOMARC Missile Site is guided by several separate documents and governmental agencies. This guidance is intended to regulate the location and intensity of potential development.

3.6.2.1 New Jersey Pinelands Comprehensive Management Plan (NJPCMP)

The Pinelands National Reserve Area (PNRA) was established through federal legislation in 1978. The PNRA consists of more than 900,000 acres of unique natural environments and species habitats (see Figure 3-16). In order to control this area, the New Jersey Pinelands Commission (1980) adopted NJPCMP. This plan established a series of development controls to preserve the integrity of the Pinelands through a permitting process that allows evaluation of proposed projects against delineated criteria contained within the plan. Plans prepared by counties and cities in the PNRA have been revised to conform to requirements of the NJPCMP.

3.6.2.2 Ocean County Comprehensive Master Plan

The Ocean County Comprehensive Master Plan was adopted in 1988 (Ocean County Planning Board, 1988a). This plan covers the entire five-mile radius land use ROI. The adopted General Development Plan, an element of the master plan, shows a continuation of existing development patterns of rural and medium density residential development, as well as areas of preservation, conservation, and recreation uses.

3.6.2.3 Local Zoning

Zoning in the nonmilitary areas of the ROI north of the site calls for agricultural and rural residential (limit/17 acres) uses.

3.6.2.4 Other Local Plans

Monmouth County is currently revising its master plan. Burlington County does not have a specific plan but instead has an approved land use map. Discussions with local planning staff indicate that areas of Burlington and Monmouth Counties immediately adjacent to Ocean County will continue to develop as low-density residential and will retain a level of agricultural activity (see Section 3.6.3.4) (Monmouth County Planning Board, 1989).

3.6.3 Future Land Uses

There are four factors influencing future development in the area. These include (1) implementation of the NJPCMP, which advocates the purchase of additional state preservation areas and restricts state and local development; (2) continued operation of federal installations; (3) proposed developments currently under consideration by local planning officials; and (4) continued use of state-supported farmland-preservation programs.

3.6.3.1 Expansion of State Conservation Areas

The NJPCMP advocates state purchase of additional areas designated for preservation. The state is considering purchase of a number of parcels in Ocean County and in the vicinity of the BOMARC Missile Site. The NJPCMP projects an additional 100,000 acres for purchase. At present, some 67,000 acres have been placed under contract and await the allocation of federal and state funds for purchase. An additional 33,000 acres are in various stages of negotiation.

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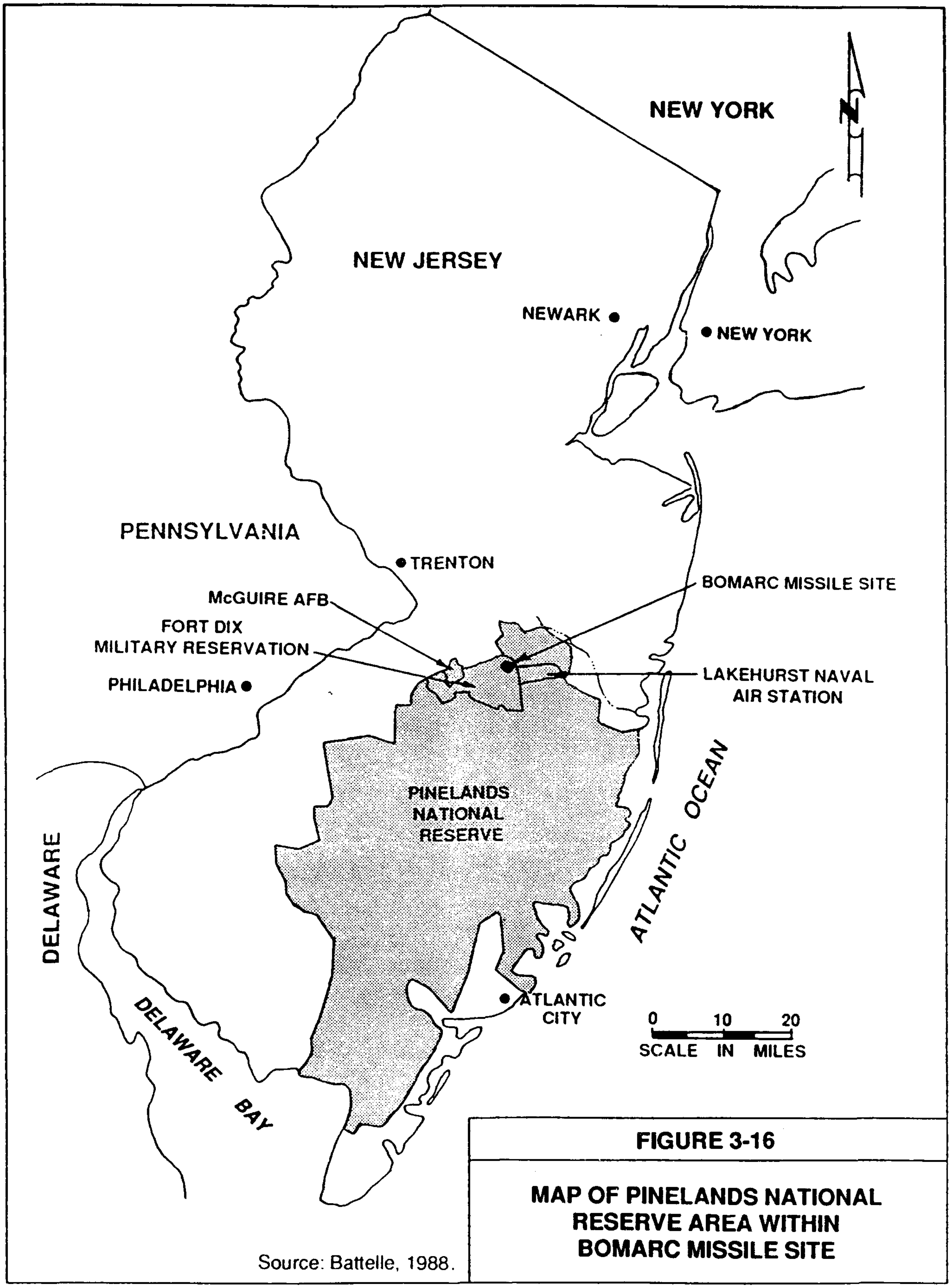

Source: Battelle, 1988.

FIGURE 3-16

MAP OF PINELANDS NATIONAL RESERVE AREA WITHIN BOMARC MISSILE SITE

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3.6.3.2 Federal Land Disposition

In April of 1991, the Defense Base Closure and Realignment Commission Report to the President recommended that Fort Dix be closed, retaining only facilities to support Reserve component training requirements. The Defense Base Closure and Realignment Commission Report indicated that some areas would be retained while excess facilities and land would be sold. None of the other installations in the area were recommended for closure.

3.6.3.3 Proposed Developments

Development proposals for Ocean County as a whole continue at the rate that has made the County the fastest growing in New Jersey since 1980. Although most of these proposals are for the eastern and southern sections of the County, there is increasing development activity in Jackson Township and Manchester Township. While these locations are in the vicinity of the BOMARC Missile Site, they are not within the five-mile radius of the land use ROI.

3.6.3.4 Farmland Preservation Programs

In 1981, New Jersey voters approved a $50,000,000 bond issue to provide matching funds for the voluntary sale of development rights from farmlands in an attempt to encourage farmland retention and active farming. In 1983, the state legislature enacted two measures: the Agriculture Retention and Development Act and the Agriculture Development and Farmland Preservation Act. These laws established a framework of agriculture development boards throughout the state that have adopted criteria for determining land desirable for agricultural retention purposes and methods to achieve those goals.

Agricultural production continues to be a major factor in the New Jersey economy. Representative production data for typical crops are shown in Table 3-15. Ocean County statistics have been highlighted, because much of this production occurs within the five-mile radius ROI.

Farmland preservation measures have been effective in Ocean County and adjacent portions of Monmouth and Burlington Counties in relieving development pressures and maintaining valuable agricultural land in active production. The State of New Jersey has recently (1989) provided an additional $50,000,000 in matching funds to expand the program.

3.6.4 Ecologically Critical Areas

Certain areas within the ROI contain unique natural vegetation and soil types for which protection from disturbance or inappropriate use is recommended by the Ocean County Comprehensive Management Plan (Ocean County Planning Board, 1988a). These lands include a combination of wetlands, marshes, bogs, hardwood swamp forests, and pitch pine lowlands (see also Section 3.5.2).

These lands play a critical role in terms of providing a recharge area for the Kirkwood aquifer. The Ocean County Comprehensive Master Plan outlines nine categories of county lands as determined by natural features. These include Tidal Wetlands, 100-Year Flood Prone Areas, Lowland Forest, Lowland Non-forest, Dwarf Forest, Prime Open Agricultural Lands, Upland

Table 3-15
Selected Agricultural Production Data for New Jersey and Ocean County in 1988

Item	State	Ocean County
Vegetables		
Tomatoes (Fresh Market)	579,500 cwt	9,500 cwt
Sweet Corn	904,000 cwt	16,00 cwt
Fruit Crops		
Cranberries	280,000 barrels	17,500 barrels
Field Crops		
Hay	287,000 tons	2,360 tons
Soybeans	3,069,000 bushels	21,600 bushels
Corn	10,450,000 bushels	114,000 bushels
Livestock		
Cattle	90,000 head	700 head
Hogs/Pigs	45,000 head	1,300 head
Equine	60,000 head	1,500 head

Source: New Jersey Department of Agriculture, 1988.

Forest, Upland Non-forest, and Extractive. Each site type was then categorized by its perceived degree of development suitability and placed in a designated class recommending methods for protection, conservation, or utilization of the land. Within the five-mile radius land use ROI, 24 resource locations have been identified as ecologically critical areas or important wetlands. These areas are listed in Table 3-16.

3.6.5 Historic and Archaeological Sites

Historic sites located adjacent to the area are mostly the remainders of small crossroads and mill site communities that developed during the eighteenth and nineteenth centuries. Presently, many of these communities are abandoned and the remaining foundations or structures are now located on federal or state land. Five of these areas are within the five-mile radius land use ROI.

There are no sites on the BOMARC Missile Site that are classified as potentially significant historic sites. Prehistoric site inventory data are incomplete as a thorough, systematic archaeological survey of the region has never been performed. Four prehistoric sites have been identified within two miles of the site. While there are no known archaeologic resource inventories for the site, past activities at the site have disturbed surface or subsurface artifacts that may have been present. The Air Force has initiated Section 106 consultation with the New Jersey State Historic Preservation Office to ensure that cultural resources, if they occur at the site, would be treated appropriately. Air Force correspondence with the New Jersey State Historic Preservation Office is included in Volume 2, Appendix 2-6.

Table 3-16
Ecologically Critical Areas within 5 Miles of the BOMARC Missile Site

Compass Direction	Feature/Resource	Distance from Site (Miles)
N	Cranberry Bogs	1
N	Cedar Swamp Area. Lakes at Colliers Mills	1.5
NNE	Cedar Swamp Area	1
NNE	NJ Wildlife Refuge at Colliers Mills	1.25
NW	Wetlands, Cedar Swamp Wetlands at Success Branch, Bordens Mills	1
ENE	confluence	0.75
ENE	Cedar Swamp Wetlands at Success Branch	2
E	Success Lake	0.5
E	Cedar Swamp Wetlands at Elisha Branch	2
ESE	Lakehurst Wetlands	0.5
ESE	Cedar Swamp Wetlands at Elisha Branch	1
SE	Cedar Swamp Wetlands at Harris Branch	0.5
SSE	Cedar Swamp Wetlands S. Source, Elisha Branch	4
S	Cedar Swamp Wetlands, Old Hurricane Brook	
SSW	No wetlands or ecologically critical areas within five miles	2
SW	Marsh wetlands/Fort Dix	2
WSW	Marsh wetlands/Fort Dix	1.25
WSW	Marsh wetlands/Fort Dix	1.5
W	Cranberry Bogs/Fort Dix	1.5
WNW	Cranberry Bogs/Fort Dix	2.25
NW	Wetlands/Jumping Brook	1.5
NW	Cranberry Bogs	2
NW	Cranberry Bogs	3.5
NNW	Hardwood Swamp Forest	1
	Cedar Swamp Wetlands	

Sources: U.S. Geological Survey, 1977; McCormick and Jones, 1973; and New Jersey Pinelands. Commission, 1980.

3.7 Transportation

This section describes the transportation routes near the BOMARC Missile Site. The transportation ROI is defined. Major and local highways, railroads and airports near the site are identified.

3.7.1 Transportation Region of Influence

For this analysis, the primary ROI has been defined to include portions of Ocean and Burlington Counties in New Jersey. Figure 3-17 shows the major transportation features of the area. Several of the alternatives evaluated in this EIS would require transportation of radioactive-contaminated material to a radioactive waste repository located outside of the primary ROI. The probable transportation route from the BOMARC Missile Site to the waste disposal site would

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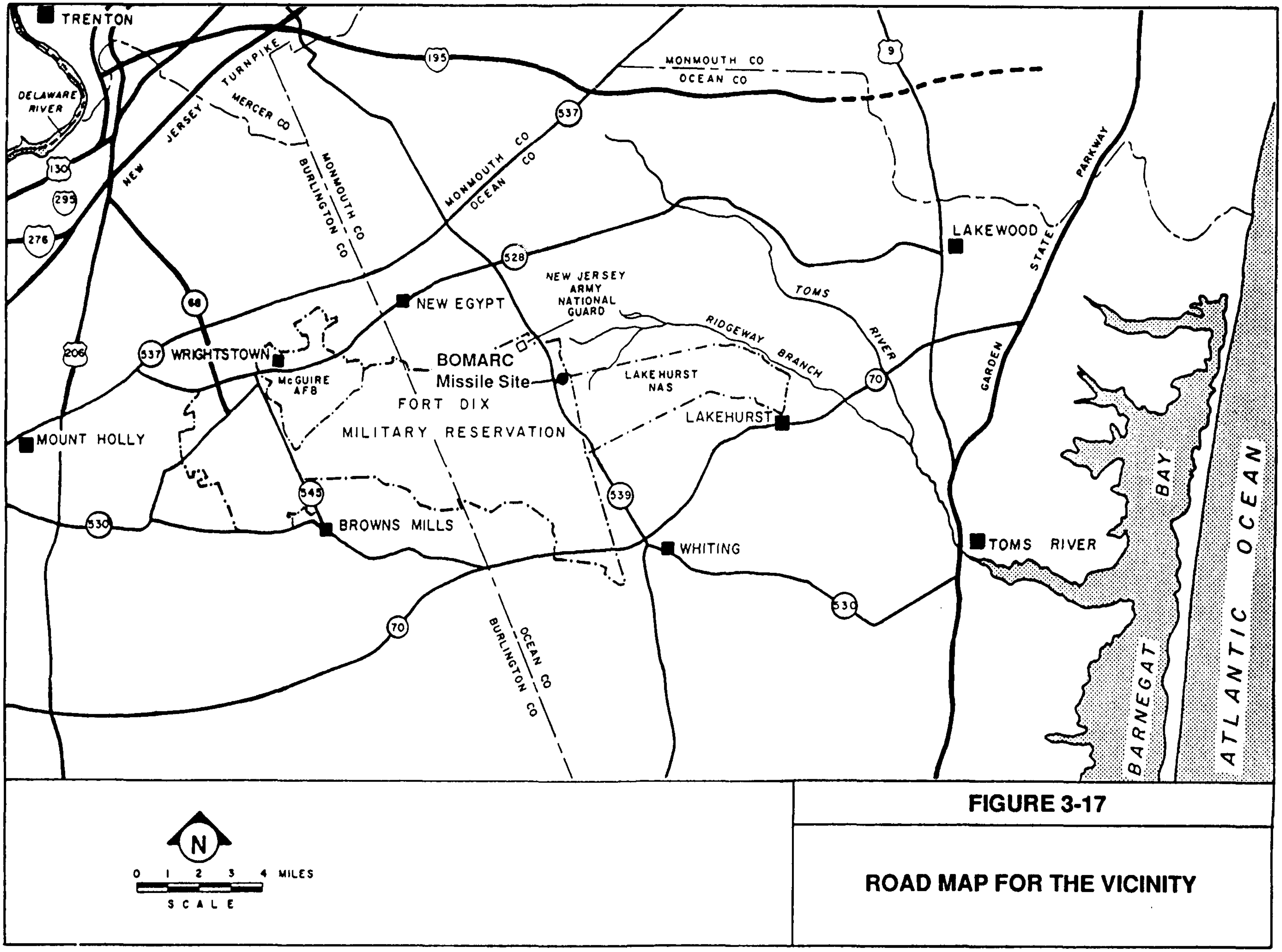

FIGURE 3-17

ROAD MAP FOR THE VICINITY

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include major highways and interstates. Major transportation routes to potential radioactive waste repositories are described in multiple documents prepared for the U.S. DOE and the NRC. These analyses are incorporated into this EIS by reference and include:

- The Transportation of Radioactive Materials by Air and Other Modes (Nuclear Regulatory Commission, 1977)
- Final EIS Disposal of Hanford Defense High Level Transuranic and Tank Wastes (U.S. DOE, 1987)
- Final EIS The Waste Isolation Pilot Plant (U.S. DOE, 1990).

3.7.2 Highways

The major highway network in the primary ROI consists of one state highway, Route 70; and portions of county Routes 539, 528, 571, 547, 530, 545; Ocean County Route 42; and Burlington County Route 616. Figure 3-16 shows the network. Ocean County Route 539 serves the BOMARC Missile Site. The other roads either feed traffic into Route 539 or comprise the shortest practical alternate route around the segment of Route 539 serving the base. Each of these roads is discussed in detail in Volume 3, Appendix 3-6. The highway network that would be used for several of the alternatives under consideration is described in previously prepared EIS's and other studies referenced earlier in this section.

3.7.3 Railroads

The BOMARC Missile Site has no rail access. The closest active rail shipping point is at Lakehurst, which is served by a 35-mile Conrail branch running between Toms River and Red Bank. Local freight service is provided over this line several days per week. There is still track in place between Lakehurst and a point southwest of Whiting, but this line is not currently active.

3.7.4 Airports

There are no civilian airports, either commercial or general aviation, within the ROI. The Robert J. Miller Air Park is located five miles southeast of Whiting along Route 530. Military airfields are located at McGuire AFB, approximately 11 miles west of the BOMARC Missile Site, and at Lakehurst NAEC, approximately four miles east of the site.

3.8 Demographics

This demographic analysis addresses an ROI that includes areas within a 50-mile radius of the BOMARC Missile Site. This 50-mile radius ROI was established by the Public Health and Atmospheric ROIs and was chosen as consistent with standard evaluation procedures for radionuclide exposure from potential atmospheric releases during remediation.

The ROI encompassing a 50-mile radius of the site includes parts of 24 counties, located within New Jersey, New York, and Pennsylvania. These counties are listed below:

NEW JERSEY (16 Counties)
Atlantic, Burlington, Camden, Cumberland, Essex, Gloucester, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Salem, Somerset, and Union.

NEW YORK (three Counties)
Kings, Queens, and Richmond.

PENNSYLVANIA (five Counties)
Bucks, Chester, Delaware, Montgomery, and Philadelphia.

These counties within the 50-mile radius ROI include three boroughs of New York City and the City of Philadelphia.

County-level and census tract-level estimates of 1980 population levels and projections for 1995 are presented in Table 3-17. Table 3-18 gives annular sector population projections for 1995 for a 50-mile radius around the BOMARC Missile Site. The counties, annular sectors, and census tracts used for the population projections are shown in Figures 3-18 and 3-19.

Projections for 1995 were chosen for this baseline because 1995 represented the data year available from all three states that most closely matched the probable date of remediation activities. County-level projections were used for areas between 5 and 50 miles of the BOMARC Missile Site. Census tract-level projections were used for areas within five miles of the site.

3.9 Radiological Characterization of Site and Environs

The radiation environment at the BOMARC Missile Site is characterized in this section. In this document, "background radiation" refers to the radiation present in the environment at the site that humans at the site would be exposed to, exclusive of any radiation from contaminated soils at the site. Radiation doses from other sources of man-made radiation (e.g., consumer products) are not included in the background radiation. The majority of the dose from background radiation is due to natural radioactivity (cosmic, terrestrial, potassium-40 (^{40}K), and radon-222 (^{222}Ra); this is discussed in Section 3.9.2. The other component of background radiation is man-made, which consists of fallout radionuclides in the soil; this is discussed in Section 3.9.3. In addition to background radiation, other man-made radioactivity and radiation contributes to the ionizing radiation exposure of the general population. These sources of exposure are discussed in Section 3.9.4. The final discussion in this section concerns radiological contamination at the BOMARC Missile Site (Section 3.9.5).

Background radiation levels vary across the U.S. depending on latitude, elevation above sea level, and the type of underlying bedrock. The average U.S. resident is estimated to receive a total effective dose equivalent (EDE) of about 300 mrem each year from background sources of radiation, of which about 200 mrem results from exposure to radon and its decay products

Table 3-17
1980 Population Levels and 1995 Population Projections for Counties within 50 Miles and Census Tracts within Five Miles of the BOMARC Missile Site

County or Census Tract	State	1980 Population	1995 Population Projection
Atlantic	NJ	194,119	237,300
Burlington	NJ	362,542	429,900
Camden	NJ	471,650	432,100
Cumberland	NJ	132,866	146,000
Essex	NJ	851,304	838,300
Gloucester	NJ	199,917	232,000
Hudson	NJ	556,972	556,700
Hunterdon	NJ	87,361	111,000
Mercer	NJ	307,863	359,700
Middlesex	NJ	595,893	711,100
Monmouth	NJ	503,173	606,700
Morris	NJ	407,630	440,000
Ocean	NJ	346,038	462,600
Salem	NJ	64,676	67,100
Somerset	NJ	203,129	243,900
Union	NJ	504,094	502,100
Kings	NY	2,231,028	2,228,361
Queens	NY	1,891,325	1,919,057
Richmond	NY	352,029	419,706
Bucks	PA	479,180	576,716
Chester	PA	316,660	379,733
Delaware	PA	555,023	541,442
Montgomery	PA	643,377	692,521
Philadelphia	PA	1,688,210	1,559,462
Ocean County Tract 173	NJ	1,433	1,712
Ocean County Tract 174	NJ	3,603	4,302
Ocean County Tract 180	NJ	4,674	4,978
Ocean County Tract 190	NJ	808	1,267
Ocean County Tract 200	NJ	4,349	7,411
Ocean County Tract 201	NJ	11,410	19,446

Source: U.S. Department of Commerce, 1980.

Table 3-18
Annular Sector Population Projections for 1995
Around the BOMARC Missile Site
(See Figure 3-18)

Distance in Miles from BOMARC Missile Site	1	2	3	4	5	10	20	30	40	50
S	0	0	0	0	32	10,071	34,931	51,605	61,753	42,067
SSW	0	0	0	0	119	8,915	32,502	50,806	58,420	69,726
SW	0	0	0	0	0	8,453	32,502	76,204	185,880	85,913
WSW	0	0	0	0	0	8,298	32,502	59,175	314,380	328,145
W	0	0	78	198	240	8,453	32,502	158,134	868,405	630,755
WNW	0	52	208	297	375	10,143	42,144	94,159	148,676	204,130
NW	0	141	214	297	375	19,400	89,976	145,215	81,479	96,614
NNW	0	134	207	280	356	17,108	104,397	145,806	98,141	83,055
N	0	0	0	203	177	14,242	94,513	238,987	282,427	479,833
NNE	0	0	0	242	236	10,967	74,492	154,901	297,060	1,656,262
NE	0	0	0	0	310	10,148	71,680	121,506	41,612	595,909
ENE	0	0	0	0	310	10,148	59,794	52,431	0	0
E	0	0	0	0	90	10,148	39,325	5,074	0	0
ESE	0	0	0	314	909	10,148	39,748	10,148	0	0
SE	0	0	52	0	1,258	10,148	39,748	33,828	0	0
SSE	0	0	122	716	1,031	10,148	39,748	57,931	22,834	0

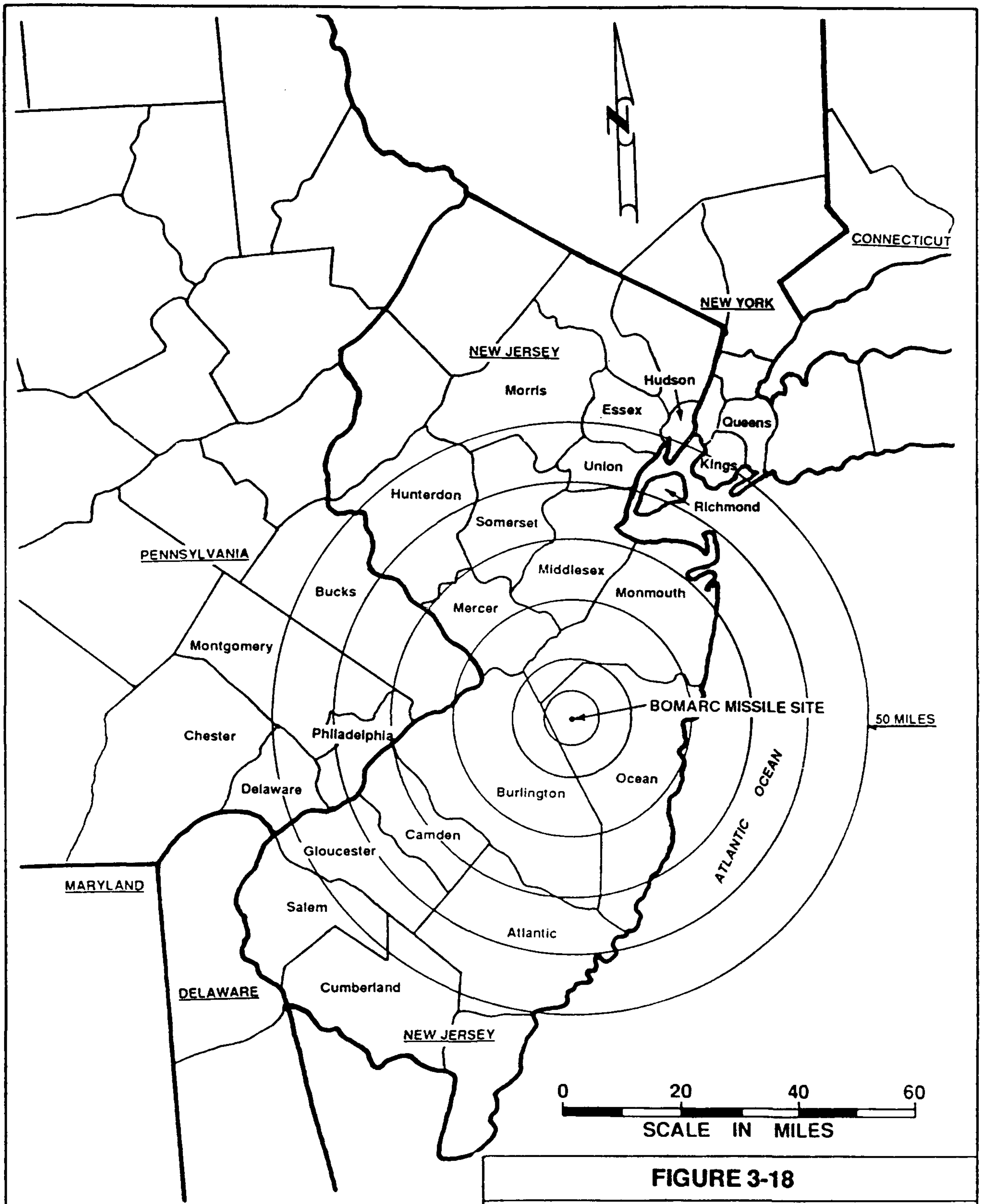

FIGURE 3-18

COUNTIES AND ANNULAR SECTORS USED FOR POPULATION PROJECTIONS BETWEEN 5 AND 50 MILES OF THE BOMARC MISSILE SITE

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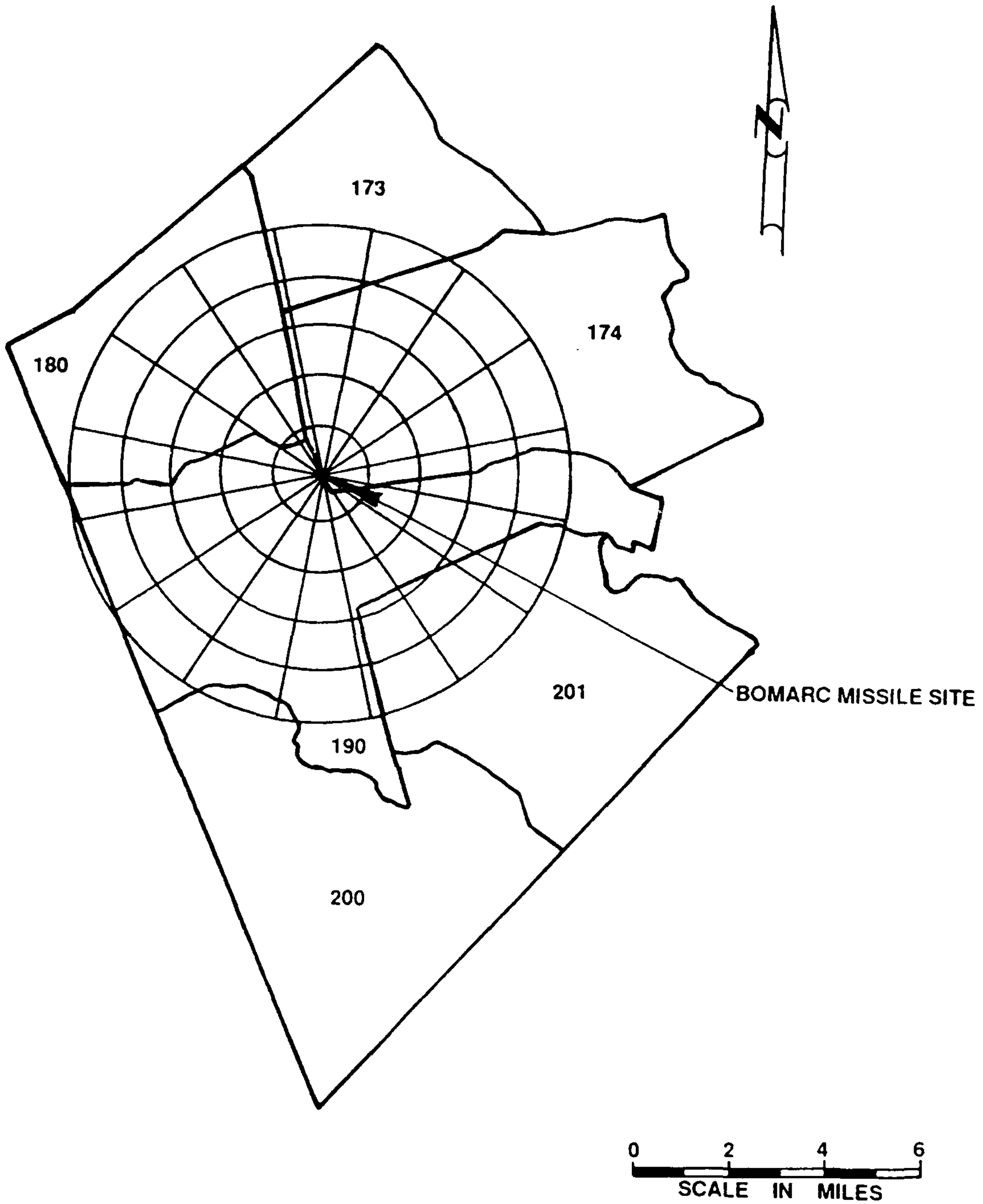

FIGURE 3-19

CENSUS TRACT AND ANNULAR SECTORS IN OCEAN COUNTY, NEW JERSEY USED FOR POPULATION PROJECTIONS WITHIN 5 MILES OF THE BOMARC MISSILE SITE

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(NCRP, 1987b). The background radiation dose estimates in Table 3-19 are more typical of dose rates for the region of the country in which the BOMARC Missile Site is located. These tabulated dose rate estimates are based on a variety of sources, including radiation surveys conducted in an uncontaminated area near the BOMARC Missile Site. Collectively, background radiation was estimated to produce an annual dose equivalent rate of about 182 mrem per year at the BOMARC Missile Site.

3.9.1 Radioactivity and Radiation: Terms

Radioactive atoms undergo spontaneous nuclear transformations and release excess energy in the form of ionizing radiation. Such transformations are referred to as radioactive decay. As a result of the radioactive decay process, one element (*parent*) is transformed into another; the newly formed element, called a *decay* (or *daughter*) *product*, will possess physical and chemical properties different from those of its *parent*, and may also be radioactive. A species of a particular element is called *nuclide*; if the nuclide is radioactive, it is referred to as a *radionuclide*. Nuclides (or radionuclides) of the same element are called *isotopes* (or *radioisotopes*) (e.g., ^{238}Pu and ^{239}Pu). Some nuclides are stable, but most are not (i.e., most are radioactive).

Over a length of time that varies by radionuclide, the atomic structure changes, or decays. The exact mode of radioactive transformation for a particular radionuclide depends solely upon its nuclear characteristics, and is independent of the nuclide's chemical characteristics or physical state. A fundamental and unique characteristic of each radionuclide is its radioactive *half-life*, defined as the time required for one half of the atoms in a given quantity of the radionuclide to decay. Half-lives for the hundreds of identified radionuclides range from fractions of a second to millions of years. The decay rate of a radionuclide, which is directly related to its half-life, is its *activity*. In this document, the unit of activity is the curie (Ci), which is equal to 37 billion disintegrations per second.

As an example, ^{239}Pu atoms decay to the initial daughter product ^{235}U at a rate corresponding to a half life of 24,400 years. ^{235}U is also radioactive, and decays with its own characteristic half life and daughter product. ^{239}Pu therefore is the beginning of a *decay chain*, in which the decay of ^{239}Pu results in a series of decay products, each one resulting from the decay of a parent, and most of them decaying in turn to a daughter product. The quantity of a radioactive daughter at any given time is dependent on the initial amount of parent and the relative decay rates of the parent and daughter. After a period of 32 years, for example, (e.g., 1960 - 1992), 1 Ci of ^{239}Pu would have decayed to 0.999 Ci, and would have produced 2.9 x 10^{-8} Ci of ^{235}U. Over a longer period of time, for example 24,400 years, an initial amount of 1 Ci of ^{239}Pu would decay to 0.5 Ci, and would result in 8.6 x 10^{-6} Ci of ^{235}U at the end of the time period. Small amounts of other daughter products in the decay chain would also exist.

Radiation emitted by radioactive substances can transfer sufficient localized energy to atoms to remove electrons from the electric field of their nucleus. Matter is said to be *ionized* when the negatively charged electrons surrounding a nucleus are separated from the positively charged nucleus. In living tissues this energy transfer can damage cellular constituents. Extensive biological damage can lead to adverse health efforts. The energy imported by radiation for a

Table 3-19
Average Annual Dose Equivalents to Individuals in the BOMARC Missile Site Region from Background Radiation[a]

Source of Background Dose Equivalent		Dose Equivalent Rate (mrem)
Natural Radioactivity		
Cosmic		40[b]
Terrestrial		9[c]
Potassium-40 and others		27[d]
Radon-222 and decay products		100[e]
Man-Made Radioactivity		
Terrestrial (fallout)		6[c]
	Total	**182**

[a] Background radiation includes natural and man-made radioactivity in the natural environment. Radiation from contamination at the BOMARC Missile Site is excluded, as is radiation from other man-made sources (see Table 3-21).

[b] Comprised of an average dose for directly ionizing radiation measured in an uncontaminated area adjacent to the BOMARC Missile Site, and a more general dose from neutrons taken from U.S. DOE (1988).

[c] Estimated from NCRP (1987b), using mean concentrations in soil samples collected from an uncontaminated area adjacent to the BOMARC Missile Site (see Table 3-20).

[d] From NCRP (1987b).

[e] Estimated by the U.S. EPA (*Federal Register*, 1986).

given mass of irradiated matter is called the *absorbed dose*. The unit of absorbed dose used in this EIS is the *rad*.

The type of ionizing radiation emitted by a particular radionuclide depends upon the exact nature of the nuclear transformation, and may include emission of *alpha particles*, electrons (*beta particles*) and *neutrons*; each of these transformations may be accompanied by emission of *photons* (gamma radiation or x rays). Each type of radiation differs in its physical characteristics and in its ability to inflict damage to biological tissue. *Dose equivalent* is the term used for dose that takes into account both the absorbed dose and the ability, or effectiveness, of different forms of radiation to cause biological harm. Dose equivalent is equal to absorbed dose multiplied by a factor, that takes into account the "biological effectiveness" (degree of harm) of a particular radiation. For photons and beta particles, the quality factor is set at unity (1); for alpha particles, the quality factor is 20. The unit used in this EIS for dose equivalent to an individual is the *rem*. The corresponding unit for the collective dose to a population (the sum of the doses to members of the population) is the *person-rem*.

The various organs of the body have different susceptibilities to harm from radiation. The quantity that takes these different susceptibilities into account to provide a broad indicator of the risk to the health of an individual from radiation is called the *EDE*. It is obtained by multiplying the dose equivalent in each major organ or tissue by a weighting factor associated with the risk susceptibilities of the tissue or organ, and then summing. The units of EDE used in this EIS are the same as for dose equivalent (rem and person-rem).

External radiation dose results from exposure to radiation from sources outside the body such as radioactive material in surface soils. *Internal* radiation dose results from radioactive material that is deposited in organs and tissues by means of ingestion or inhalation. Both naturally occurring and man-made radioactivity can result in either an external or an internal radiation dose.

3.9.2 Background Radiation Dose from Natural Radioactivity in the Environment

External dose from natural radiation comes primarily from two sources: cosmic radiation (i.e., from outside the earth) and terrestrial (from the surface of the earth). Cosmic radiation originates from the universe and is composed of fast neutrons, helium nuclei, and nuclei of heavier elements. The annual cosmic radiation dose from ionizing radiation at the BOMARC Missile Site is estimated to be approximately 34 mrem per year. This estimate is based on a radiological survey made near the BOMARC Missile Site in 1988 (New Jersey Department of Environmental Protection, 1988b). Exposure rate measurements were taken at 272 points on a 25 by 25 foot grid in a five-acre study site located adjacent to the BOMARC Missile Site in an uncontaminated area. The average of these measurements is 5.6 μrem per hour, which is equivalent to 49 mrem per year. The cosmic radiation portion of this total was obtained by estimating and subtracting the contribution from terrestrial radiation (see next paragraph and Section 3.9.3). The average cosmic radiation dose from neutrons (six mrem per year) was obtained from the U.S. DOE (1988).

The other source of external radiation dose from natural radiation exposure is terrestrial radiation from primordial radionuclides (i.e., radionuclides present in the earth since its creation). The major radiation dose contributors include the uranium isotopes, primarily ^{235}U and ^{238}U, and their radioactive decay products [primarily Thorium-232 (^{232}Th)]. Radioactive decay products form as a result of the spontaneous breakdown of radioactive atoms into one or more different elements. Results of analyses for radionuclides in surface soil samples, zero to six inches, collected from a study site adjacent to the BOMARC Missile Site are shown in Table 3-20. Using tables from the National Council on Radiation Protection and Measurements Report No. 94 (NCRP, 1987b), and average measured concentrations of these radionuclides, the dose from external exposure to naturally occurring terrestrial radionuclides was calculated to be approximately nine mrem per year.

Table 3-20
Background Radionuclide Activity Concentrations in Surface (0-6 Inches) Soils of an Uncontaminated Area Adjacent to the BOMARC Missile Site

Radionuclide	Range of Activity Concentrations (pCi/g)	Mean Activity Concentration (pCi/g)
^{40}K	BDL[a] to 1.54 ± 0.24	0.62[b]
^{226}Ra	BDL[a] to 1.70 ± 0.52	0.34[b]
^{232}Th	BDL[a] to 0.45 ± 0.08	0.20[c]
^{235}U	BDL[a]	BDL[a]
^{238}U	BDL[a] to 1.54 ± 0.24	0.22[c]
^{137}Cs	0.2 ± 0.05 to 0.60 ± 0.08	0.41[d]

Source: NJDEPE, 1988b.
[a] BDL = below detection limit.
[b] Geometric mean obtained using the probability plotting method recommended by Corley *et al.* (1981).
[c] Arithmetic mean obtained using the probability plotting method recommended by Corley *et al.* (1981).
[d] Geometric mean.

One of the principle contributors to internal radiation dose from naturally occurring radioactivity is ^{40}K. This isotope accounts for a small fraction of all naturally occurring potassium, 1.17 percent. When ingested in foodstuffs, ^{40}K is incorporated in human tissues in proportion to its natural abundance and results in a radiation dose of about 27 mrem per year to the average person in the U.S.

Most of the remainder of the internal radiation dose from natural radioactivity results from ^{222}Rn and its decay products. The dose from radon varies widely from one location to another across the U.S. According to recent U.S. EPA estimates, the inhalation of short-lived ^{222}Rn and its decay products results in an average EDE of about 100 mrem per year in the United States (*Federal Register*, September 30, 1986). No site-specific measurements of radon have been made. Radon concentrations are typically highly variable. However, soil radium content at the site does not suggest that any unusually high concentrations of ^{222}Rn would be found.

3.9.3 Background Radiation Dose from Man-Made Radioactivity in the Environment

External radiation dose from terrestrial radiation can also result from man-made radionuclides deposited on the ground. Globally distributed radionuclides from nuclear weapons testing fallout are responsible for the majority of man-made radioactive material detected in most soils. Atmospheric testing ended in 1980, and nearly all fallout radioactivity resulted from testing before 1975. Thus, the majority of the dose from fallout has already been delivered. The significant radiation dose contributors that remain in surface soil include ^{90}Sr, ^{137}Cs, and ^{239}Pu. Results of analyses performed to determine the concentration of ^{137}Cs in surface soils adjacent to the BOMARC Missile Site show a range of values from 0.2 to 0.6 pCi per g and an average value of 0.41 pCi per g (Table 3-20). No analyses were conducted for ^{90}Sr and ^{239}Pu. However, using observed isotopic ratios (Eisenbud, 1973), and accounting for decay, estimated activity concentrations of 0.26 and 0.013 pCi per g were calculated for ^{90}Sr and ^{239}Pu, respectively. These values would result in an external exposure rate of approximately 6 mrem per year. The internal dose that could potentially be received from these radionuclides was investigated using the RESRAD computer program and an agriculture scenario used for estimating the dose to the farming intruder (see Section 4.2.1 of Volume 3, Appendix 3-8). The resulting dose was less than one mrem per year and thus is not included in Table 3-19.

3.9.4 Radiation Dose from Other Sources of Man-Made Radiation

In addition to background radiation, there are other sources of radiation dose to the public. These sources are from man-made radioactivity and radiation, and include occupational exposures, the nuclear fuel cycle for production of electrical power, radiation from consumer products, and medical diagnosis and treatment. The average annual dose to individuals in the U.S. from these sources is summarized in Table 3-21.

Table 3-21
Radiation Doses from Other Sources of Man-Made Radiation[a]

Source	Average Annual U.S. Dose (mrem)
Occupational Exposures	0.9
Nuclear Fuel Cycle	0.05
Consumer Products	6-13
Medical	
Diagnostic X-rays	39
Nuclear Medicine	14
Miscellaneous[b]	≤1
Rounded Total	60

Source: NCRP, 1987a, b.
[a]Radiation dose from nuclear weapons testing fallout is not included (see Table 3-19).
[b]Miscellaneous includes DOE facilities, smelters, transportation, etc.

There are four nuclear power plants operating within approximately 50 miles of the BOMARC Missile Site: Limerick near Philadelphia, and Hope Creek, Salem, and Oyster Creek in New Jersey. In addition, experimental fusion machines are operated at Princeton University. The occupational and public radiation doses resulting from these operations and from operation of various fuel cycle facilities are not expected to result in any measurable change in background radiation level in the vicinity of the BOMARC Missile Site (i.e., much less than one mrem per year).

The major contributors to mean radiation doses from consumer products are domestic water supplies (about 1 to 6 mrem per year), building materials (about 3.5 mrem per year), and combustible fuels (about 3.5 to 6.5 mrem per year). Collectively, these sources (mostly natural radiation enhanced by human uses) account for about 6 to 13 mrem per year. Other sources, such as color televisions, video display terminals, false teeth, airport luggage inspection, radioluminous products, smoke detectors, etc., typically contribute small fractions of the total (NCRP, 1987c).

3.9.5 Radioactive Contamination at the BOMARC Missile Site

Plutonium (primarily ^{239}Pu) and americium (^{241}Am) are the principle radionuclides of concern at the BOMARC Missile Site. They belong to a group of elements known as actinides, which includes the elements from atomic number 90 (thorium) through 103 (lawrencium), all of which are radioactive. In general, the chemistry of the actinides is extremely complex. However, the behavior of plutonium in the environment, and particularly the oxides of plutonium, has been sufficiently studied to permit reliable assessment calculations.

The WGP found at the BOMARC Missile Site consists of approximately 93 percent ^{239}Pu and 7 percent ^{240}Pu, with smaller quantities of ^{238}Pu and ^{241}Pu. Both ^{239}Pu and ^{240}Pu have very long half-lives (see Table 3-22) and have not decayed significantly since the accident. A half-life is the time necessary for half of the radioactive isotope to decay. ^{241}Pu, however, has a relatively short half-life of 13.2 years, so that roughly 80 percent of the amount involved in the accident had decayed away as of December, 1990. As each nucleus of ^{241}Pu decays, one nucleus of ^{241}Am with a half-life of 458 years is produced. As a consequence, ^{241}Am is also of concern at the BOMARC Missile Site. Based on soil sampling data (SAIC, 1990), the ratio of ^{239}Pu to ^{241}Am activity at the BOMARC Missile Site is 5.9:1.

The radiological contamination at the BOMARC Missile Site consists of WGP. The primary isotope in WGP is ^{239}Pu, but small quantities of ^{238}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am are also present. These contaminants are found in or on soil, concrete, asphalt, steel, and possibly glass. The radioactive contamination is not distributed uniformly over the site but occurs in discrete "hot spots," which, in several instances, have been found to be a single particle, presumably containing plutonium oxide. Thus, measurements within a small area can and do vary. This variation is seen in samples that have been drawn from the same location but at different times. Generally, however, the samples indicate that the levels of contamination have remained stable over the intervening years.

Table 3-22
Radiological Properties of Specific Nuclides of Plutonium and Americium of Concern at the BOMARC Missile Site

	^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	^{241}Am
Half Life (years)	8.78×10^1	2.44×10^4	6.58×10^3	1.32×10^1	4.58×10^2
Primary Radiation	ALPHA	ALPHA	ALPHA	BETA	ALPHA
Energy (Mev)	5.50	5.16	5.17	0.021	5.49
Secondary Radiation		GAMMA			PHOTON
Energy (Mev)		0.017			0.060
Initial Daughter Product	^{234}U	^{235}U	^{236}U	^{241}Am	^{237}Np

Source: Kocher, 1981.

Several air samples were collected from locations around Shelter 204 as part of the BOMARC Missile Site RI/FS for the purpose of defining a baseline concentration of radionuclides in the ambient air prior to site activities. The air sampling showed both gross alpha and beta concentrations to be well below regulatory guidelines (see Section 4.1.3.3 of the RI/FS).

The oxides of plutonium and americium are relatively insoluble in water and have a high affinity for soil particles. As a consequence, these elements are not highly mobile in the environment and are not readily taken up by plants and animals. This is illustrated by the values of the four parameters typically used for assessment purposes to define the movement of radionuclides through food chains (see Table 3-23). These parameters (K_d, B_v, F_f, F_m) are described in the following paragraphs.

The distribution coefficient, K_d, is the ratio between radioactivity adsorbed to soil (pCi per g) and that in solution in surrounding water (pCi per ml). Values of the K_d for a given element vary widely depending on site-specific properties of both soil and water. Americium is generally more mobile than plutonium, and has a range of K_d in fresh water of about 10^2 to 4×10^4. Plutonium has a range under similar conditions of about 10^2 to 10^7. These high values indicate that the actinides adsorb strongly into soils, and would not be expected to move readily in solution. Any significant dispersion of actinides in the environment is most likely due to movement of soil particles themselves, either as wind-blown dusts or as waterborne sediments. The K_d values are given in Table 3-23.

Table 3-23
Selected Environmental Transport Parameters for Plutonium and Americium[a,b]

	K_d (ml/g)	B_v	F_f (d/kg)	F_m (d/L)
Plutonium	2.0×10^{4}	2.0×10^{-3}	4.1×10^{-7}	4.5×10^{-8}
Americium	4.0×10^{2}	2.1×10^{-3}	1.6×10^{-6}	2.0×10^{-5}

a. K_d = distribution coefficient.
B_v = ratio between concentration in the above-ground portions of plants growing in soil (pCi/g) and concentration in soil (pCi/g).
F_f = ratio between concentration in beef (pCi/kg) and daily intake by beef cattle (pCi/d).
F_m = ratio between concentration in cow's milk (pCi/L) and daily intake by dairy cows (pCi/d).
b. Source for K_d values: Isherwood, 1981. Source for B_v, F_f, and F_m values: Till and Meyer (1983).

The parameter B_v is the ratio between concentration in the aboveground portions of plants growing in soil (pCi per g), and concentration in soil (pCi per g). As indicated in Table 3-23, plant concentrations of both elements are generally about 500 times smaller than concentrations in soil. The transfer coefficient, F_f, is the ratio between concentration in beef (pCi per kg) and daily intake by beef cattle (pCi per d). The transfer coefficient, F_m, is the ratio between concentration in cow's milk (pCi per L) and daily intake by dairy cows (pCi per d). The values in Table 3-23 indicate that low uptake by animals results in very low concentrations in animal products used for human consumption.

SECTION 4.0

ENVIRONMENTAL CONSEQUENCES

4.0 ENVIRONMENTAL CONSEQUENCES

The potential environmental impacts of the five alternatives under consideration are assessed in this section. The alternatives that are evaluated are: Unrestricted Access, NEPA No Action, Limited Action, Off-site Disposal (the preferred alternative), and On-site Treatment. A detailed description of each of the alternatives is given in Section 2.0. The following subsections provide a brief summary of each of the five alternatives and a discussion of the potential environmental consequences of these alternatives. Impacts to the geology and soils, hydrology, air quality, biology, land use, transportation, and public health are assessed. Mitigations which would be employed to lessen impacts associated with each remediation are also discussed. Environmental impacts are assigned one of four impact levels (negligible, low, moderate, or high) based on quantitative and qualitative factors discussed in the Appendices to the EIS. High impacts were evaluated for significance based on the significance criteria which are also discussed in the Appendices to the EIS.

4.1 Unrestricted Access Alternative

If the worst-case scenario were to occur, the Air Force would lose control of the site. Contaminated materials would remain in place, and the current management practices which include institutional access controls, monitoring, and maintenance would be discontinued. No remedial measures would be implemented.

The potential impacts which would result from implementation of this alternative are directly related to the activities that would occur at the site. This alternative would leave the site available for a variety of potential uses in the distant future which cannot be predicted. Therefore, the nature and magnitude of the impacts resulting from this alternative are speculative. Sections 4.1.1 through 4.1.7 provide a discussion of the impacts that would likely occur if the natural processes occurring at the site would continue unaltered by human intervention. A brief discussion of the potential impacts that could occur if invasive development activities would occur at the site is also provided.

4.1.1 Geology and Soils

If the Unrestricted Access Alternative were to occur, geologic baseline conditions (topography, stratigraphy, geological structure, geological resources, unconsolidated rock deposits, and soils) within the BOMARC Missile Site would not be altered if the natural processes occurring at the site continued unaltered by human intervention. If this alternative were to occur, the current potential for erosion of contaminated soils would be altered and soils could eventually be transported off-site via wind and/or water. The concrete apron and the asphalt drainage ditch lining would, as long as they remained intact, serve to contain and reduce plutonium and americium migration by isolating underlying soils from erosional processes. Over time, however, the concrete and asphalt would deteriorate and expose underlying contaminated soils. The Oak-Pine forest would develop; however, this vegetation would not be expected to prevent as much soil erosion as would an asphalt or concrete cap. Thus, potential for erosion would increase overall. The Unrestricted Access Alternative would not reduce extant levels of soil contamination at the site. As discussed in Section 3.2.8.4, the migration of plutonium through soil occurs at a relatively slow rate. Americium is slightly more mobile than plutonium, but both are strongly adsorbed by soil. Therefore, soil erosion would be the primary transport medium. The universal soil loss equation (USLE) was used to predict erosional soil losses from contaminated areas of the site. Based on a number of assumptions the USLE estimated a loss of 0.17 tons of soil per acre per year from the wooded contaminated area and a loss of 0.7 tons of soil per acre per year from the grassy contaminated areas (see Section 3.2.8.5 for complete discussion of the USLE and the computations). Over the past 30 years, sediment transport, originating from water erosion, may have deposited contamination along the site drainage gradient to the ponding area. Over time, on-site plutonium- and americium-contaminated soil could eventually be transported off-site down the drainage gradient to the Elisha Branch.

If this alternative were to occur, the potential for transport of contaminated soils off-site via erosion would increase slightly. Therefore, the environmental consequences resulting from this alternative are estimated to be low if the natural processes occurring at the site continued unaltered by human intervention. Excavation and development of the site in the future without any engineering controls at contaminated areas could create the potential for high impacts which could be significant.

4.1.2 Hydrology

Consequences that would result from the Unrestricted Access Alternative, if it were to occur, on surface and groundwater are discussed below.

4.1.2.1 Surface Water

If the Unrestricted Access Alternative were to occur, the surface water baseline conditions would be altered within the BOMARC Missile Site.

Surface water quality would not be altered under the Unrestricted Access Alternative. The gross alpha emissions detected in suspended sediments suggest that some radionuclides are presently transported in the south flowing drainage ditch, though levels are very low. Gross alpha emissions could result from naturally occurring radionuclides. The water itself is not likely to be a source of radioactivity as plutonium and americium are insoluble and adsorb to fine soil. Thus, surface water quality would not be altered by the Unrestricted Access Alternative.

Surface water quantity and flow rate would be altered if the Unrestricted Access Alternative were to occur. Existing impervious structures, such as the concrete apron, would not be maintained. As a result, the concrete and asphalt would deteriorate. Deterioration of the concrete and asphalt would increase infiltration and decrease the run-off from rainfall events. There could be channel adjustment resulting from changes in hydrologic and sediment transport regimes. This would primarily affect the upper Elisha Branch. Contaminant transport via the surface water pathway at the BOMARC Missile Site is partially mitigated naturally by drainage conditions. The subdued site topography would mitigate the potential for off-site transport of radionuclides. The decrease in run-off would further reduce the potential for erosion and sediment transport. Impacts associated with the Unrestricted Access Alternative would be low as surface water flow regimes would be slightly altered if the natural processes occurring at the site continued unaltered by human intervention. However, excavation and development of the site without any engineering controls at contaminated areas could create the potential for high impacts which could be significant.

4.1.2.2 Groundwater

If the Unrestricted Access Alternative were to occur, the groundwater baseline conditions would be slightly altered within the BOMARC Missile Site.

Groundwater quantities and flow rates would be slightly altered under the Unrestricted Access Alternative. Existing impervious structures, such as the concrete apron, would not be maintained. The infiltration of rainwater into the sandy soils in the area is currently low at the site, due to the presence of the mostly impervious surfaces. Deterioration of these impervious surfaces would increase infiltration rates to more natural conditions. However, because of the low solubility and strong soil adsorption of plutonium and americium, radionuclide availability for transport through the groundwater would be very low. As discussed in Section 3.3.3.3, groundwater sampling and analysis indicated that no radioactivity associated with plutonium could not be detected. This situation would continue if the Unrestricted Access Alternative were to occur.

The Unrestricted Access Alternative would not be expected to alter groundwater quality. Groundwater quantity and flow rate would return to more natural conditions. Therefore, impacts to groundwater associated with the Unrestricted Access Alternative would be low if the natural processes occurring at the site continued unaltered by human intervention. However, excavation and development of the site could create the potential for high impacts which could be significant.

4.1.3 Air Quality

Estimation of impacts to air quality is directly dependent on the ultimate land use and associated development activities, which range from natural processes to invasive development activities. The Unrestricted Access Alternative would not alter baseline air quality conditions if the natural processes occurring at the site would continue unaltered by human intervention. The site would experience periods of greater or lesser fugitive dust generation relating to periods of dry, windy conditions versus periods of wet soil and lesser wind speeds, respectively. However, if the site were to remain undisturbed, the successional changes in the vegetative cover would result in an Oak-Pine or oak hickory climax community that would reduce the exposure of soils to wind erosion and lessen the potential of airborne transport of particulates. The lack of intrusive activities would also preclude the mechanical generation of fugitive dust and associated secondary impacts (such as impacts associated with increased local vehicular traffic). Therefore, air quality impacts would be negligible. However, in the absence of any institutional controls, there would be no restrictions on activities at the site. This would result in the potential for activities such as excavation to occur. Excavation without any engineering controls would result in the generation and airborne transport of fugitive dust, as well as gaseous exhaust products (carbon monoxide, nitrogen and sulfur oxides, and hydrocarbons) and secondary impacts. Because long-term end uses are not known, the magnitude of potential emissions cannot be practically assessed. It must therefore be assumed that, as a worst-case, this alternative could result in high impacts to air quality which could be significant.

4.1.4 Biology

If the Unrestricted Access Alternative were to occur, it would be expected to alter the vegetative habitat at the site and in the ROI. As discussed below, relative distribution of species at the site would be expected to change. The potential for plant uptake or animal ingestion and inhalation would not be altered. Flora, fauna and the potential biological assimilation of plutonium and americium are discussed separately below.

4.1.4.1 Flora

The Oak-Pine vegetative habitat would not be substantially disturbed by the Unrestricted Access Alternative if the natural processes occurring at the site continued unaltered by human intervention. However, the old field vegetative zone would ultimately be displaced. Under the Unrestricted Access Alternative, the vegetation on-site would not be maintained (mowed or cut). As a consequence, continued successional change would eventually result in the old field vegetative zone developing into an Oak-Pine community or an oak-hickory climax community. Two New Jersey threatened plant species *Chrysopsis falcata* (sickle-leaved Golden Aster) and *Juncus greenei* (Greene's Rush) were observed growing near the central area of the site during the ecological field work conducted for this EIS. These plants have thrived under current conditions, which include mowing and regular upkeep of the grounds. The Unrestricted Access Alternative would result in successional change and the displacement of the current old field habitat and the two threatened plants. The Unrestricted Access Alternative would have a low impact on floral communities if the natural processes occurring at the site continued unaltered by human intervention. However, excavation and development of the site could create the potential for high impacts which could be significant if habitats are destroyed or altered or if populations are disrupted.

4.1.4.2 Fauna

If the Unrestricted Access Alternative were to occur, it would not result in substantial negative changes in: animal distribution; status of threatened or endangered species; status of sensitive or critical habitats; or communities or food chain and interspecies relationships at the BOMARC Missile Site if the natural processes occurring at the site continued unaltered by human intervention. However, cessation of maintenance activities, such as mowing, at the site would result in normal successional change. The old field habitat would develop into Oak-Pine forest or an oak-hickory climax community. Changes would result in the occurrence of fauna species because of habitat preference. For example, red and gray squirrels are better adapted for an arboreal habitat and may migrate into the area as the old field habitat changes to a forested community. Therefore, the Unrestricted Access Alternative would have low impacts on faunal communities. However, excavation and development of the site could create the potential for high impacts which could be significant if habitats are destroyed or altered, or if populations are disrupted.

4.1.4.3 Organism Contamination Analysis

This section discuses the potential that the Unrestricted Access Alternative would have for altering the potential for biological assimilation of radionuclides by flora and fauna. The principal potential biological impacts of the Unrestricted Access Alternative would be the increased potential for off-site transport of plutonium and americium.

Plutonium released into the environment is not concentrated by terrestrial plants (Hakonson *et al.*, 1981; McLeod *et al.*, 1981). Soil-plant uptake, measured as a percentage of plant-plutonium concentration to soil concentration (i.e., the concentration factor), has been found to be extremely low based on a number of greenhouse experiments (Bennett, 1976). Soil-plant concentration factors ranged from 3×10^{-2} to 4×10^{-8} for plutonium. Americium concentration factors were also found to be very low. The results of research performed by Oak Ridge National Laboratory (Baes *et al.*, 1984) placed the soil to plant concentration factor at 0.0055 for americium.

Even though plutonium and americium are not bioconcentrated in plant tissue, soil particles containing these contaminants could be deposited upon plant surfaces (leaves, bark stems, etc.) through agents of soil transport (wind and water erosion). These processes could potentially cause plutonium and americium to be bioavailable for herbivores inhabiting the BOMARC Missile Site ROI. However, the magnitude of plant to animal concentration for ^{239}Pu from ingestion of plants grown in plutonium-contaminated soils also appears to be very low or negligible (Bennetti, 1976, Romney, *et al.*, 1970).

Human and experimental standards have indicated that inhalation of suspended contaminated soils is a critical route of entry (Whicker, 1980). Implementation of the Unrestricted Access Alternative would eliminate institutional control over the site. There would be no control over future activities which would increase the potential for inhalation of contaminated soils.

At present there are few potential faunal receptors living in and/or on contaminated soils at the site. The soils of the Pinelands do not support significant populations of invertebrates. Despite excavation of six soil test pits during the RI/FS, the total number of specimens collected was of insufficient mass for a single analysis. During the RI/FS, numerous attempts were conducted to collect small mammals. One white-footed mouse was captured and subsequently analyzed. The analytical results (from alpha spectrometry) indicated that the ^{239}Pu and ^{241}Am levels of the mouse were below the instrument detection limits (^{239}Pu - 1.0×10^{-3} pCi per g, ^{241}Am - 3.0×10^{-2} pCi per g). Although the potential for exposure would increase as the barriers to entry deteriorate, soil-plant uptake of the contaminants is low and the potential for ingestion of contaminated plants by animals is also low. However, the potential for inhalation of contaminated soils would be higher. If the Unrestricted Access Alternative were to occur, it would have negligible impacts on flora and low impacts on fauna due to the potential for contaminant inhalation if the natural processes occurring at the site would continue unaltered by human intervention. However, excavation and development of the site without any engineering controls at contaminated areas could create the potential for high impacts. These impacts could be significant if invasive development activities occurred which increase the potential for bioaccumulation of airborne contamination.

4.1.5 Land Use

Impacts that would result if the Unrestricted Access Alternative occurred were evaluated in the context of the planning horizons that would be affected. The horizons that are evaluated are the current and future. Current is defined as the planning horizons specified in the land use plans that have been adapted by the jurisdictions adjacent to the site. Future was defined as the timeframe for which comprehensive plans have not been developed. Impacts were assessed based on the potential that an alternative would conflict with current land use plans or could conflict with future land use plans. The use of areas identified as prime farmland, located within five miles of the site, would not be directly altered if this alternative were implemented.

4.1.5.1 Short-Term

The Unrestricted Access Alternative would not substantially alter land uses within the jurisdictions proximate to the site. It was assumed that for this horizon, land uses in the adjacent jurisdictions would remain static or continue as outlined in current land use plans. It was also assumed that no invasive activities would occur at the site. The potential for conflicts between this alternative and present land uses in adjacent jurisdictions is summarized below.

McGuire AFB

The majority of McGuire AFB lies 11 miles west of the BOMARC Missile Site in Burlington County. This is beyond the 5-mile radius used as the land use ROI. The development strategy for McGuire AFB shows that future development at the base would not be in substantially different areas or represent substantial shifts from current land use patterns. Therefore, the Unrestricted Access Alternative would not be in conflict with development plans at McGuire AFB.

Fort Dix

The BOMARC Missile Site is located at the eastern edge of Fort Dix, and is surrounded on its northern, western, and southern boundaries by that installation. Major portions of the eastern part of the base are occupied by marsh and bog lands. Permanent housing is not located in that area. The majority of permanent structures at Fort Dix are located in Burlington County, beyond the five-mile radius land use ROI. No master plan for Fort Dix exists. Fort Dix was recommended for base closure. Therefore, the Unrestricted Access Alternative would not conflict with future land use and development at Fort Dix.

Lakehurst NAEC

The Lakehurst NAEC is located southeast of the BOMARC Missile Site. Residential development at the Lakehurst NAEC is limited to the eastern edge of the property, and falls outside the 5-mile land use ROI.

The short-term land use plan for Lakehurst NAEC indicates that changes are expected in the next 5 to 6 years. This plan indicates that residential development and associated recreational and support facilities would remain limited to the eastern edge of the property over the short-term. The 20-year land use plan includes changes that are expected to occur over the next 20 years. This plan does not indicate any substantial alteration of land use during that time. Specifically, the 20-year plan does not indicate that there would be any major changes in land use for the western portion of the facility, within the 5-mile ROI for the BOMARC Missile Site. Therefore, the Unrestricted Access Alternative would not be in conflict with either the short-term or 20-year development plans at Lakehurst NAEC.

Colliers Mills Wildlife Management Area

The Colliers Mills Wildlife Management Area (WMA) is located to the northeast of the BOMARC Missile Site, adjacent to both Fort Dix and Lakehurst NAEC, and within the 5-mile ROI for land use. Colliers Mills WMA is administered by the Division of Fish, Game and Wildlife. The acquisition of additional preservation lands is a stated goal of the Pinelands Comprehensive Management Plan. This area has been designated as a preserve to be expanded, and preliminary negotiations have occurred with adjacent landowners. If the Unrestricted Access Alternative were to occur, there would not be conflicts with the present uses of the Colliers Mills WMA.

Ocean County

The major development in Ocean County is occurring in the southern portion of the County. These areas are beyond the 5-mile radius of the land use ROI.

The community of New Egypt is partially located within the five-mile land use ROI. It is situated northwest of the BOMARC Missile Site. While it has some new residential and commercial development, this community has not experienced as much development pressure as other communities in the region. The Ocean County development plan indicates low to moderate growth. No substantial changes are expected in the land uses around the community of New Egypt. Therefore, the Unrestricted Access Alternative would not be in conflict with present and future land use patterns.

Burlington County

Most of Burlington County is outside the 5-mile land use ROI for the BOMARC Missile Site. The area of the County that is encompassed by the ROI falls exclusively within the borders of Fort Dix and is under its developmental jurisdiction. The Unrestricted Access Alternative would not be in conflict with Burlington County's land use plans.

Monmouth County

Monmouth County falls outside the 5-mile land use ROI of the BOMARC Missile Site. As discussed above, the land uses proximate to the site are primarily low density and agricultural. This alternative would not conflict with existing uses or land use plans.

Based on the assumptions identified, there were no potential conflicts between this alternative and current land use or land use plans in the adjacent jurisdictions. Therefore, impacts would be negligible.

4.1.5.2 Long-Term

Future impacts to land uses within the jurisdiction proximate to the site cannot be predicted without assuming potential end uses at the site. As a worst case, it was assumed that in the long-term, in the absence of institutional control, invasive activities could occur. It was also assumed that land uses in adjacent jurisdictions could change from low density, agricultural to high density, residential. As a result, implementation of this alternative could result in uses of the site that create conflicts with future land use plans in adjacent jurisdictions. Therefore, the Unrestricted Alternative Action could have moderate impacts on land use in the long-term.

4.1.6 Transportation

The Unrestricted Access Alternative would not alter the transportation infrastructure and would not change the pattern or volume of traffic in the local area if the natural processes occurring at the site continued unaltered by human intervention. Therefore, implementation of this alternative would have negligible impacts on transportation. However, future unpredictable developments of the site could create the potential for high impacts to occur to the transportation infrastructure near the BOMARC Missile Site if traffic volumes increase significantly.

4.1.7 Public Health

The Unrestricted Access Alternative would result in public health impacts at the site, as a result of eliminating the access controls and allowing members of the public access to the site. Public health impacts resulting from this alternative relate primarily to radionuclide exposure. Under undisturbed conditions, the radiological conditions at the site would not be significantly altered. However, under the intruder scenario described for this alternative, a member of the public establishes a residence in contaminated soil. As part of this worst-case scenario, the intruder contacts the buried launcher during excavation of a basement. The highly-contaminated soil immediately surrounding the launcher is assumed to be contaminated and distributed around the residence, thereby increasing the level of surface contamination at the site. Therefore, public health impacts would affect individual members of the public (i.e., the intruder), as well as the off-site population. These two types of analyses - individual and population - were conducted to estimate the magnitude of potential public health impacts. The results of these analyses for the Unrestricted Access Alternative are discussed below, and are summarized in Table 4-1.

4.1.7.1 Radiation Dose to Inadvertent Intruders

The Unrestricted Access Alternative would result in the loss of institutional controls and physical barriers at the site. Therefore, the maximum potential dose to an individual would be for inadvertent intruders. These are hypothetical individuals that may move onto the BOMARC Missile Site at some indefinite time in the future and establish residence there without knowledge of the existing contamination. This is a highly unlikely event that is analyzed as a worst-case scenario. Even though such a scenario may be unlikely in the foreseeable future for the BOMARC Missile Site, it cannot be excluded as noncredible at some time several hundred years in the future. Potential impacts for individual intruders are expressed in units of radiation dose (mrem per year) as an EDE to the entire body and as an organ dose equivalent to bone surface, liver, and lung. Background information on the behavior of plutonium in the environment and

Table 4-1
Unrestricted Access Alternative
Summary of Public Health Consequences

	Calculated Impact	Level of Impact
Individual		
Intruder - Construction	540 mrem	High
Intruder - Residence	745 mrem/yr	High
Population		
Collective Dose	5.3 person-rem/yr	Negligible
Collective Risk	1.7×10^{-3} cancers/yr	Negligible

*Doses are expressed as the EDE.

associated risks is provided in Section 3.9 of the EIS, supplemented by Volume 3, Appendix 3-8. Estimated radiation doses to individuals are best compared to natural background radiation (49 mrems per year). A discussion of the natural radiation environment near the BOMARC Missile Site is presented in Section 3.9 of this document.

If this alternative were to occur, the bounding circumstances for potential radiological impact to an individual are given by a scenario in which an intruder disturbs the buried launcher during construction of a house. For a worst-case scenario, it is assumed that all unaccounted contamination is associated with the missing launcher. Potential doses from excavation work are estimated using a scenario adapted from that used by the NRC for waste disposal assessments (Kennedy and Peloquin, 1988). The NRC assumes that this scenario would occur after the shutdown of operations at a disposal facility. The general outline of this scenario used by the NRC is directly applicable to the BOMARC Missile Site. In the NRC scenario, institutional controls are assumed to break down and an intruder inadvertently constructs a house on the disposal facility. Although the BOMARC site is not a disposal facility, there are a sufficient number of similarities between the two that the NRC scenario can be used. Additional details of this scenario are provided in Volume 3, Appendix 3-8, Section 3.2.

The construction/residence scenario consists of two parts. First, it is assumed that the intruder contacts the radioactive contamination associated with the buried missile launcher while performing excavation work associated with the construction of a basement for a house. Second, following house construction, the intruder takes up residence on the site and grows food crops in soil contaminated with both existing surface soil radioactivity and some additional radioactivity resulting from disturbing the missile launcher during excavation.

The potential for radiation exposure to an intruder during the excavation of a basement and disturbance of the buried launcher would be significant. The estimated total dose for this phase of the scenario is 540 mrem. While single radiation doses of this magnitude have not been shown to result directly in adverse health effects, this dose is 3 times in excess of the annual background radiation dose for the vicinity of the BOMARC Missile Site, and would have a high impact on the intruder. It is essentially equal to the 500 mrem allowed by Federal Regulation for a single exposure of any member of the general public in the vicinity of an NRC Licensed facility (10 CFR Part 20).

The potential for radiation exposure to an intruder residing on the site following excavation of a basement and disturbance of the buried launcher would also be significant. The estimated annual dose rate for this phase of the scenario is 745 mrem per year. This dose rate is about 4 times the annual background radiation dose in the vicinity of the BOMARC Missile Site, and could have a high impact on the intruder.

Radiation doses to a hypothetical residential intruder would be dominated by inhalation of ^{239}Pu-contaminated resuspended dust. This route of exposure would account for approximately 40 percent of the total dose during the construction phase and 60 percent during the residence phase. Inhalation of ^{241}Am-contaminated dust would contribute about 7 percent during construction and about 10 percent during the residence phase. Ingestion of plutonium and americium was not considered as part of the construction phase but would account for about 25 percent of the dose during the residence phase. During the residence phase, the external gamma radiation dose (primarily from ^{241}Am) would account for less than one percent of the total. However, during the construction phase, this exposure pathway would account for approximately half of the total dose. For the residence phase, waterborne radioactivity would not make a significant contribution, even for calculations taken out to periods of greater than 1,000 years.

4.1.7.2 Potential Radiation Dose to the Surrounding Population

The second type of public health analysis estimates the potential collective dose to the population within 50 miles of the site due to airborne releases of radioactivity from resuspended surface contamination. Potential impacts for populations are expressed in units of collective radiation dose (person-rem per year) as an EDE and as organ dose equivalents to bone surface, liver, and lung. In addition, radiation doses to large populations can be related directly to cancer incidence rates. Therefore, potential impacts to the surrounding population are also expressed in terms of excess fatal cancers. A discussion of the association between radiation exposure and subsequent cancer risks from internally deposited alpha emitters such as ^{239}Pu and ^{241}Am is presented in Section 1.2 of Volume 3, Appendix 3-8.

The potential collective dose to the population within 50 miles of the BOMARC Missile Site from resuspension and subsequent atmospheric dispersion of contaminated material was evaluated using the methods described in Section 3.1 of Volume 3, Appendix 3-8. The collective dose rate of 5.3 person-rem per year would be distributed over a population of about 9.2 million persons within 50 miles. The estimated excess fatal cancer rate would be very much less than one per year (1.7×10^{-3} cancers per year) in the population of 9.2 million persons. This cancer incidence rate can be compared to a natural incidence that exceeds 2,500 fatal cancers per year per million persons. This natural incidence rate would correspond to a lifetime incidence of approximately 20,000 cancer deaths per 100,000 individuals (National Research Council, 1990). The estimated collective dose rate of 5.3 person-rem per year is below the 100 person-rem per year lower limit established for a low impact in Section 4.2 of Volume 3, Appendix 3-8.

Therefore this population dose is considered negligible. The corresponding cancer rate is also in the negligible category. Therefore, the public health impacts to the surrounding population, if this alternative were to occur, would be negligible.

4.2 NEPA No Action Alternative

This alternative would consist of continuation of operational procedures currently practiced at the site. These include: restricting public access to the site; preventing deterioration of existing containment structures; monitoring the distribution and potential migration of plutonium and americium on-site and off-site; and preventing disturbance of the site. These operational procedures would continue to be accomplished through the implementation of the following actions: installation and maintenance of fencing and signs; quarterly visual inspections; maintenance of concrete apron; radiological surveys once every 5 years; and deed restrictions. Potential impacts resulting from implementation of the NEPA No Action Alternative are provided in Sections 4.2.1. through 4.2.7. Mitigations are provided in Section 4.6.

4.2.1 Geology and Soils

Implementation of the NEPA No Action Alternative would not alter geologic baseline conditions (topography, stratigraphy, geological structure, geological resources, unconsolidated rock deposits, and soils) within the BOMARC Missile Site. Implementation of this alternative would not alter the potential for erosion of contaminated soils, which could eventually be transported off-site via wind and/or water. The concrete apron and the asphalt drainage ditch lining would be maintained and would serve to contain and reduce plutonium and americium migration by isolating the underlying soils from erosional processes. However, any plutonium and americium contamination in soils outside these maintained areas would be subjected to erosional processes, which could eventually transport them off-site (See Section 4.1.1). Implementation of the NEPA No Action Alternative would not reduce extant levels of soil contamination at the site.

Contaminated soils under the concrete and asphalt would remain undisturbed if this alternative were implemented. The potential for transport of non-capped contaminated soils off-site via erosion would remain the same. Therefore, environmental consequences resulting from implementation of this alternative are estimated to be negligible.

4.2.2 Hydrology

The impacts of implementation of the NEPA No Action Alternative on surface and groundwater are discussed below.

4.2.2.1 Surface Water

Implementation of the NEPA No Action Alternative would not alter the surface water baseline conditions within the BOMARC Missile Site. Surface water quality, quantity and flow rate are discussed below.

Implementation of the NEPA No Action Alternative would not result in degradation of current surface water quality. The gross alpha measurements for suspended sediments suggest that some radionuclides could be transported in the south flowing drainage ditch, though levels are very low. Gross alpha levels could result from naturally occurring radionuclides. The water itself is not likely to be a source of radioactivity as plutonium and americium are insoluble and adsorb to fine soil. Thus, surface water quality would not be altered by implementation of the NEPA No Action Alternative.

Surface water quantity and flow rate would not be altered with implementation of the NEPA No Action Alternative. Existing impervious structures and surfaces, such as the concrete apron, would be maintained. These surfaces would continue to create lower-than-natural infiltration conditions. The current volumes and flow rates of the surface water runoff would be maintained. Presently, there are no known negative impacts associated with surface water runoff from the BOMARC Missile Site. Thus, implementation of the NEPA No Action would have negligible impacts on surface water.

Implementation of the NEPA No Action Alternative would not alter the current condition of surface water quality, quantity and flow rate. The impacts associated with the NEPA No Action Alternative would be negligible.

4.2.2.2 Groundwater

Implementation of the NEPA No Action Alternative would not alter the groundwater baseline conditions within the BOMARC Missile Site. Groundwater quality, quantity, and flow rate are discussed below.

Groundwater quality would not be altered under the NEPA No Action Alternative. As discussed in Section 3.3.3.3, on-site groundwater sampling and analysis indicated that radioactivity associated with plutonium could not be detected. Due to the insoluble nature of the contaminants and their adsorption to soils, contaminants are not likely to be found in the groundwater. This situation would continue under implementation of the NEPA No Action Alternative.

Groundwater quantity and flow rate would not be altered with implementation of the NEPA No Action Alternative. Existing impervious structures such as the concrete apron would be maintained. The infiltration of rainwater into the sandy soils in the area would remain generally low due to the presence of the mostly impervious surface at the site.

Groundwater quality, quantity and flow rate would not be altered from current conditions by the implementation of the NEPA No Action Alternative. Impacts associated with the NEPA No Action Alternative would be negligible.

4.2.3 Air Quality

The NEPA No Action Alternative would result in some generation of fugitive dust due to foot and vehicular traffic associated with routine maintenance, inspections, and surveillance activities, on-site and around the perimeter, other occasional ground disturbances, and gaseous exhaust from vehicles and heavy equipment. This alternative also requires limited disturbance (approximately 100 yd^3) of the site associated with the construction of a perimeter fence. Activities which would be used to mitigate fugitive dust emission during these construction activities are discussed in Section 4.6. Maintenance and surveillance activities would be conducted intermittently, for an indefinite period. In addition to these limited periods of mechanical disturbance, wind erosion will contribute to minor increases in fugitive dust loading.

This alternative would result in minimal, short-term (on the order of a few months) increases in ambient levels of particulate matter and gaseous exhaust products, such as carbon monoxide, nitrogen and sulfur oxides, and hydrocarbons, as well as some generation of fugitive dust by wind erosion. It would not be expected to result in violation of any AAQS or impact the attainment status of the area. Implementation of the NEPA No Action Alternative would result in negligible impacts to air quality.

4.2.4 Biology

Implementation of the NEPA No Action Alternative would not be expected to substantially alter the vegetative habitat at the site or in the ROI. Both the total number and relative distribution of species at the site and the potential for plant uptake or animal ingestion and inhalation of contaminants would remain the same. Flora, fauna, and the potential biological assimilation of plutonium and americium are discussed separately below.

4.2.4.1 Flora

The Oak-Pine vegetative habitat would not be substantially disturbed by implementation of the NEPA No Action Alternative. Mowing, cutting, and groundskeeping measures would continue. The natural process of plant succession would be prevented. Therefore, the flora within the site fence and outside the control zone would be continuously maintained in an early phase of old field succession. The resultant vegetation assemblage would be very similar to the present on-site old field vegetation zone with its predominance of herbaceous plants (grasses, composites, etc.) and relative absence of woody vegetation such as shrubs or trees.

Two New Jersey threatened plant species *Chrysopsis falcata* (sickle-leaved Golden Aster) and *Juncus greenei* (Greene's Rush) were observed growing near the central area of the site during the ecological fieldwork conducted for this EIS. These plants have thrived under current conditions, which include mowing and regular upkeep of the grounds, and they would be expected to continue to thrive if the NEPA No Action Alternative were to be implemented. Implementation of the NEPA No Action Alternative would have negligible impacts on floral communities.

4.2.4.2 Fauna

Implementation of the No Action Alternative would not be expected to change animal distribution, status of threatened or endangered species, status of sensitive or critical habitats or communities, or food chain and interspecies relationships within the BOMARC Missile Site ROI. This alternative provides for continuous maintenance of site fences, thus limiting site access for larger mammals with relatively wide home ranges such as raccoons, foxes, or deer. With regular mowing and upkeep of the area, the natural process of plant succession would be prevented, thus maintaining the old field habitat within the site boundary. Implementation of the NEPA No Action Alternative would have negligible impacts on faunal communities.

4.2.4.3 Organism Contamination Analysis

This section discusses the potential that implementation of the NEPA No Action Alternative has for either increasing or decreasing the possibility of biological assimilation of radionuclides by flora and fauna. The potential for plutonium and americium bioconcentration in plant tissues and its biotransport is low, as discussed in Section 4.1.4.3. Implementation of the NEPA No Action Alternative would not substantially change the potential bioavailability and bioassimilation of plutonium and americium within the site's ROI. Access to the site would be restricted. However, as discussed in Section 4.2.1, erosional forces could move contaminated soils outside the fenced area. As described in Section 4.1.4.3, the soils of the Pinelands do not support significant populations of invertebrates. Thus the low potential bioavailability of plutonium and americium, combined with the relative paucity of receptors at the site and the lack of dust-generating activities, suggest that bioaccumulation would not be problematic. With respect to the potential for bioassimilation, implementation of the NEPA No Action Alternative would have negligible impacts on flora and fauna.

4.2.5 Land Use

Implementation of this alternative would not be expected to alter land use patterns relative to McGuire AFB, Lakehurst NAEC, Colliers Mills Wildlife Management Area, or Burlington, Ocean, or Monmouth Counties for the same reasons summarized in Section 4.1.5. Generally this conclusion is based on the remoteness of the site from adjacent non-military properties, the agricultural and rural low-density nature of the existing development, and the lack of significant development pressure due to controls in regional and local land use plans and zoning ordinances. There would not be potential conflicts between this alternative and current land uses or land use plans in the adjacent jurisdictions. The use of areas identified as prime farmland, located within five miles of the site, would not be directly altered if this alternative were implemented. Therefore, the potential short-term impacts are negligible.

Since institutional controls would be maintained, no invasive activities would occur at the site. Future land uses in the adjacent jurisdictions are speculative. The surrounding land use could change from low density rural to high density urban. Access to the site would be controlled; the potential to use the site for productive purposes would be forgone. Therefore, there is a potential that this alternative could conflict with future land use plans and potential impacts could be moderate.

4.2.6 Transportation

Implementation of the NEPA No Action Alternative would not alter the transportation infrastructure and would not change the pattern or volume of traffic in the local area. There would be a few daily vehicle trips to the site by the fence installation crew, health physicists, maintenance crews, radiological survey crew, and inspection personnel. These workers would only access the site for short periods (e.g., one month for the fence installation crew, one week per year for maintenance crews). The vehicle volumes generated by these site users would be a nominal percentage of the average daily traffic on the area roadways. Therefore, implementation of the NEPA No Action Alternative would have a negligible impact on transportation near the BOMARC Missile Site.

4.2.7 Public and Occupational Health

Implementation of the NEPA No Action Alternative would not alter the public or occupational health impacts of the site. Current controls, maintenance, and monitoring, which would be continued under this alternative, would keep these impacts to a minimal level. Health impacts resulting from the NEPA No Action Alternative relate primarily to radionuclide exposure which could affect nearby residents or workers on the BOMARC Missile Site. These are discussed below.

4.2.7.1 Public Health Impacts

Implementation of the NEPA No Action Alternative would result in the continuation of institutional and physical controls at the site; this would result in the continued restricted access to the site by members of the public. Therefore, public health impacts would consist only of potential impacts to the off-site population. Radiation dose from contamination at the BOMARC Missile Site is the potential impact of greatest concern. The results of the public health impacts analyses for the NEPA No Action Alternative are presented below and are summarized in Table 4-2.

Table 4-2
NEPA No Action and Limited Action Alternatives
Summary of Public Health Consequences

	Calculated Impact	Level of Impact
Individual	N/A	N/A
Population		
Collective Dose	2.7 person-rem/yr	Negligible
Collective Risk	9.1×10^{-4} person-rem/yr	Negligible

* Doses are expressed as the EDE.

N/A = Not Applicable

4.2.7.1.1 Radiation Dose to Inadvertent Intruders

The NEPA No Action Alternative would include continuation of institutional controls and physical barriers to prevent inadvertent intrusion. It is assumed that members of the public would not be able to inadvertently intrude the site. Therefore, significant doses to individual members of the public would not be possible.

4.2.7.1.2 Potential Radiation Dose to the Surrounding Population

The potential collective dose to the population within 50 miles of the BOMARC Missile Site from resuspension and subsequent atmospheric dispersion and of contaminated material was evaluated as described in Section 4.1.7.2 and Section 3.1 of Volume 3, Appendix 3-8. The estimated collective dose rate for this alternative of 2.7 person-rem per year would be distributed over a population of about 9.2 million persons within 50 miles. The estimated total excess fatal cancer rate would be very much less than one per year (9.1×10^{-4} cancers per year) in the population of over nine million persons. This cancer incidence rate can be compared to a natural incidence that exceeds 2,500 cancers per year per million persons. This natural incidence rate would correspond to a lifetime incidence of approximately 20,000 cancer deaths per 100,000 individuals (National Research Council, 1990). The estimated collective dose rate of 2.7 person-rem per year is less than the 100 to 1,000 person-rem per year range established for a low impact in Section 4.2 of Volume 3, Appendix 3-8. The corresponding cancer rate is also below the low category. Therefore, the public health impacts to the surrounding population from this alternative would be negligible.

4.2.7.2 <u>Occupational Health</u>

The NEPA No Action Alternative would not alter occupational health impacts. Adequate worker health and safety controls are ensured under Occupational Safety and Health Administration (OSHA) regulations (Title 29, CFR) Subpart 1910.120 Hazardous Waste Operations and Engineering Response and other applicable subparts.

4.3 Limited Action Alternative

The Limited Action Alternative is similar to the NEPA No Action Alternative. The primary difference is that the Limited Action Alternative includes searching for the missile launcher and, if found, removing it.

This alternative would consist of several actions designed to protect human health and the environment by: restricting of public access to the site, preventing deterioration of existing containment structures, monitoring the distribution and potential migration of plutonium and americium on-site and off-site, preventing disturbance of the site, and locating and removing the missile launcher, if possible.

These goals would be accomplished through implementation of the following actions: installation and maintenance of fencing and signs; quarterly visual inspections; maintenance of concrete apron; annual radiological surveys; deed restrictions; and excavation and disposal of missile launcher and disposal of associated contaminated soils. To locate the missing missile launcher, areas around the five geophysical anomalies identified during the RI/FS that might represent the missile launcher would be excavated and visually inspected. All five anomaly areas could require excavation. If the launcher is found, the launcher and surrounding soils would be characterized with respect to radioactivity, and the launcher and contaminated soils would be excavated. Contaminated soils and the launcher would be containerized and hauled to a licensed disposal facility.

Potential impacts resulting from the implementation of the Limited Action Alternative are discussed in Subsections 4.3.1 through 4.3.7. Mitigations are discussed in Section 4.6.

4.3.1 Geology and Soils

Implementation of the Limited Action Alternative would not alter geologic baseline conditions (topography, stratigraphy, geological structure, geological resources, unconsolidated rock deposits, and soils) within the BOMARC Missile Site. Implementation of this alternative would alter the potential for erosion of contaminated soils in the short term if the missile launcher is located and excavated, thus disturbing soils. The short-term potential for increased soil erosion during launcher excavation would be controlled by engineering and safety procedures. Therefore, the potential for soil erosion would remain the same resulting in negligible short-term impacts to soils.

The concrete apron and the asphalt drainage ditch lining would be maintained if this alternative were implemented. This would serve to contain and reduce plutonium and americium migration by isolating the underlying soils from erosional processes. However, any plutonium and americium contamination in soils outside these maintained areas would be subjected to erosional processes, so the potential for soil erosion would remain the same. Implementation of the Limited Action Alternative would reduce levels of soil contamination at the site only if the missile launcher is found. In the long term, contaminated soils would remain since presently contaminated soils would not be disturbed. The potential for transport of contaminated soils off-site via erosion would remain the same. Environmental consequences resulting from implementation of this alternative are estimated to be negligible.

4.3.2 Hydrology

Hydrologic consequences of implementation of the Limited Action Alternative on surface and groundwater are discussed below.

4.3.2.1 Surface Water

Implementation of the Limited Action Alternative would not alter the surface water baseline conditions within the BOMARC Missile Site. Surface water quality, quantity and flow rate are discussed below.

Surface water quality would not be altered under the Limited Action Alternative. The gross alpha emissions detected in suspended sediments suggest that some radionuclides are presently transported in the south flowing drainage ditch, though levels are very low. Gross alpha emissions could result from naturally occurring radionuclides. The water itself is not likely to be a source of radioactivity as plutonium and americium are insoluble and adsorb to fine soil. Disruptive activities, such as soil excavation, would be localized and short-term. Thus, surface water quality would not be altered by implementation of the Limited Action Alternative.

Surface water quantity and flow rate would not be altered by implementation of the Limited Action Alternative. Excavation activities associated with searching for the launcher would create the potential for a short-term increase in soil and sediment erosion due to soil disturbance and exposure. The total area affected would be small and engineering controls would be utilized to minimize impacts. Over the long-term, existing impervious structures, such as the concrete apron would be maintained. These surfaces would continue to create lower-than-natural infiltration conditions. The current volumes and flow rates of the surface water runoff would be maintained. Presently, there are no negative impacts associated with surface water runoff from the BOMARC Missile Site.

Surface water quality, quantity, and flow rate would not be altered from current conditions by the implementation of the Limited Action Alternative. Short-term and long-term impacts associated with the Limited Action Alternative would be negligible.

4.3.2.2 Groundwater

Implementation of the Limited Action Alternative would not alter the groundwater baseline conditions within the BOMARC Missile Site. Groundwater quality, quantity, and flow rate are discussed below.

Groundwater quality would not be degraded under the Limited Action Alternative. As discussed in Section 3.3.3.3, groundwater sampling and analysis on-site indicated that no radioactivity associated with plutonium could be detected. Groundwater quality would not change with implementation of the Limited Action Alternative.

Groundwater quantities and flow rates would not be altered with implementation of the Limited Action Alternative. Existing impervious structures, such as the concrete apron, would be maintained. The infiltration of rainwater into the sandy soils in the area would remain generally low due to the presence of the mostly impervious surface at the site. Implementation of the Limited Action Alternative would have negligible short- and long-term impacts on groundwater.

Groundwater quality, quantity, and flow rates would not be altered from current conditions by the implementation of the Limited Action Alternative. Impacts associated with the Limited Action Alternative would be negligible.

4.3.3 Air Quality

Implementation of the Limited Action Alternative would result in some generation of fugitive dust by mechanical activities such as traffic on unpaved access roads, gaseous exhaust from vehicles and heavy equipment, and secondary impacts such as vehicular exhaust along the disposal route. Activities related to maintaining current conditions for this alternative are discussed in Section 4.2.3. The Limited Action Alternative also involves potential excavation and disposal of the launcher and associated contaminated soils (approximately 100 yd^3), thus increasing the potential for fugitive dust generation as well as secondary impacts. Activities which would be used to mitigate fugitive dust emissions during these excavation/construction activities are discussed in Section 4.6.

This alternative would result in short-term (on the order of a few months) increases in ambient levels of particulate matter and gaseous exhaust products such as carbon monoxide, nitrogen and sulfur oxides, and hydrocarbons, as well as some wind erosion. These impacts are considered to be low. It would not be expected to result in violation of any AAQS or impact the attainment status of the area. Long-term impacts to air quality would be negligible. Secondary impacts along the transport route would also be negligible. Implementation of the Limited Action Alternative would result in low impacts to air quality.

4.3.4 Biology

Implementation of the Limited Action Alternative would not be expected to substantially alter the vegetative habitat at the site or in the ROI and would not substantially alter the total number or relative distribution of species at the site. In the long term, the presently low potential for plant uptake or animal ingestion and inhalation would be further reduced if the launcher were discovered, excavated, and removed. Flora, fauna and the potential biological assimilation of plutonium and americium are discussed separately below.

4.3.4.1 Flora

The Oak-Pine vegetative habitat would not be substantially disturbed by implementation of the Limited Action Alternative. The old field vegetative zone would be temporarily disturbed. Excavation of the launcher would result in localized disruption of vegetation. The total area affected would be small; therefore, the short-term impacts would be negligible.

Mowing, cutting, and groundskeeping measures would be implemented as part of this alternative, thus preventing the natural process of plant succession. The flora within the site fence and outside the control zone would be continuously maintained in an early phase of old field succession. The resultant vegetation assemblage would be very similar to the present on-site old field vegetation zone which is predominantly herbaceous plants (grasses, composites, etc.).

Two New Jersey threatened plant species *Chrysopsis falcata* (sickle-leaved Golden Aster) and *Juncus greenei* (Greene's Rush) were observed growing near the central area of the site during the ecological fieldwork conducted for this EIS. Site activities associated with the Limited Action Alternative include excavating areas in search of the launcher and mowing or regular upkeep of the grounds. Excavation activities could indirectly disturb or destroy these plant species even though the plants are not growing in areas that would be excavated. These impacts would be mitigated (see Section 4.6). Therefore potential long-term impacts to flora would be negligible.

4.3.4.2 Fauna

Implementation of the Limited Action Alternative would not be expected to change animal distribution, status of threatened or endangered species, status of sensitive habitats or communities, or food chain and interspecies relationships within the BOMARC Missile Site ROI. The total area of the habitats (Oak-Pine forest habitat and Old-field habitat) would not change substantially. Therefore, short-term and long-term implementation of the Limited Action Alternative would be expected to have negligible impacts on faunal communities.

4.3.4.3 Organism Contamination Analysis

This section discusses the potential that implementation of the Limited Action Alternative has for either increasing or decreasing the possibility of biological assimilation of radionuclides by flora and fauna.

In the short term, excavation activities associated with the search for the missile launcher would potentially generate fugitive dust. Human and experimental standards have indicated that inhalation of suspended contaminated soils is a critical route of entry (Whicker, 1980). Although there are few faunal receptors at the site, the potential would exist for the inhalation of contaminants during excavation. These potential impacts would be local, temporary, and would be expected to be low.

The potential for plutonium and americium bioconcentration in plant tissues and bioassimilation and its biotransport off-site by herbivores is low and is discussed in Section 4.1.4.3. Implementation of this alternative would not change the rate or potential for off-site transport of plutonium and americium in the long term, thus having negligible long-term impacts.

4.3.5 Land Use

Implementation of this alternative would not be expected to significantly alter current land use patterns relative to McGuire AFB, Lakehurst NAEC, Colliers Mills Wildlife Management Area, or Burlington, Ocean, or Monmouth Counties for the same reasons summarized in Section 4.2.5. This conclusion is based on the remoteness of the site from adjacent nonmilitary properties, the agricultural and rural low-density nature of the existing development, and the lack of significant development pressure due to controls in regional and local land use plans and zoning ordinances. Activities associated with searching for the missile launcher would be temporary and minor. There would not be potential conflicts between this alternative and current land uses or land use plans in the adjacent jurisdictions. The use of areas identified as prime farmland, located within five miles of the site, would not be directly altered if this alternative were implemented. Thus, implementation of the Limited Action Alternative would have negligible impacts.

Since the institutional controls would be maintained, no invasive activities would occur at the site. Future long-term land uses in the adjacent jurisdictions are speculative. The surrounding land use could change from low density, rural to high density, urban which would create the potential for impacts. Access to the site would be controlled; the potential to use the site for any productive purpose would be forgone. Therefore, there is a potential that this alternative could conflict with future land use plans, and potential impacts could be moderate.

4.3.6 Transportation

Implementation of the Limited Action Alternative would not alter the transportation infrastructure nor noticeably change the pattern or volume of traffic in the local area. However, if the missile launcher is located, it would be excavated; the launcher and associated contaminated soils would require off-site disposal. Internal site traffic would increase as contaminated soil would be transported to a drop-off point for packaging. All contaminated materials would be placed in 9-foot × 9-foot × 16-foot truck-sized containers (48 yd^3 capacity) for off-site transport. It is assumed that excavation activities would generate, as a worst case, approximately 10 truck loads of contaminated materials. It is also assumed, as a worst case, that all off-site truck trips would be completed in a one-week period. This would result in two truck trips per day. Mitigation measures (discussed in Section 4.6) would be used to minimize this minor additional load. This would not affect the local transportation infrastructure nor would it alter local patterns or volumes of traffic.

Implementation of this alternative would require the transportation of contaminated materials from the BOMARC Missile Site to an off-site waste repository. The location of the radioactive waste disposal site has not yet been determined. Potential sites that would receive the contaminated waste include the Nevada Test Site and U.S. Ecology's Hanford, Washington, site. Regardless of the travel corridors that are used for transport, four trucks per day would be a nominal percentage of average daily traffic. This conclusion is based on the assumption that the travel path to a disposal site would consist of major roadways such as state routes, U.S. highways, interstates, and other highways. These types of roadways are conducive to relatively high-volume traffic, and a few trucks per day would not significantly affect the performance of that type of roadway. Thus, implementation of the Limited Action Alternative would have negligible short-term impacts on the transportation infrastructure, traffic volumes, or patterns.

The relative risks associated with transportation of radioactive wastes have been evaluated in a variety of documents. These analyses assess the potential environmental impacts associated with land transportation of radioactive wastes. The analyses include:

- The Transportation of Radioactive Materials by Air and Other Modes (Nuclear Regulatory Commission, 1977)
- Final EIS Disposal of Hanford Defense High Level Transuranic and Tank Wastes (U.S. Department of Energy, 1987)
- Final EIS The Waste Isolation Pilot Plant (U.S. Department of Energy, 1990).

Transportation of radioactive wastes are regulated by several Federal agencies and a myriad of State agencies. Implementation of this alternative would require compliance with all relevant regulatory requirements. In general, previous EIS's and studies which have evaluated the issue related to transportation of radioactive wastes have concluded that transportation of radioactive wastes in compliance with applicable regulations does not pose a threat of significant impacts to the environment. Thus, short-term impacts to transportation would be negligible.

In the long-term, implementation of the Limited Action Alternative would not alter the transportation infrastructure near the BOMARC Missile Site in the primary ROI. There would be a few daily vehicle trips to the site by the fence installation crew, health physicists, maintenance crews, radiological survey crew, and inspection personnel. These workers would only access the site for short periods (e.g., one month for the fence installation crew, one week per year for maintenance crews). The vehicle volumes generated by these workers would be a nominal percentage of the average daily traffic on the area roadways. Because traffic volume increases would be nominal, no increased maintenance would be expected, and the incidence of accidents should not change. Therefore, implementation of the Limited Action Alternative would have negligible long-term impacts to transportation.

4.3.7 Public and Occupational Health

Implementation of the Limited Action Alternative would not significantly alter the public or occupational health impacts of the site. Current controls, maintenance, and monitoring, which would be continued under this alternative, are keeping these impacts to a minimal level. Health impacts resulting from the Limited Action Alternative relate primarily to radionuclide exposure, which could affect nearby residents or workers on the BOMARC Missile Site. These are discussed below.

4.3.7.1 Public Health Impacts

Implementation of the Limited Action Alternative would result in the continuation of institutional and physical controls at the site; this would result in the continued restricted access to the site by members of the public. Therefore, public health impacts would consist only of potential impacts to the off-site population. Radiation dose from contamination at the BOMARC Missile Site is the potential impact of greatest concern. The results of the public health impacts analyses for the Limited Action Alternative are presented below and are summarized in Table 4-2.

4.3.7.1.1 Radiation Dose to Inadvertent Intruders

The Limited Action Alternative would include establishing institutional controls and physical barriers to prevent inadvertent intrusion. It is assumed that members of the public would not be able to inadvertently intrude onto the site. Therefore, significant doses to individual members of the public would not be possible.

4.3.7.1.2 Potential Radiation Dose to the Surrounding Population

Implementation of the Limited Action Alternative would result in the same average surface soil concentration of plutonium as for the NEPA No Action Alternative. Therefore, the potential collective dose to the population within 50 miles of the BOMARC Missile Site from atmospheric dispersion of contaminated material would be exactly the same as for that calculated for the NEPA No Action Alternative (Section 4.2.7.1.2), and public health impacts would be negligible.

4.3.7.2 Occupational Health

Implementation of the Limited Action Alternative would slightly increase the occupational health impacts over the current level. This would result from the activities associated with excavation and removal of the launcher, and would be a short-term impact. Several measures would be used to ensure that potential occupational impacts are kept to negligible levels (see Section 4.6). Adequate worker health and safety controls are further ensured by compliance with all applicable regulations and guidelines of the OSHA in Title 29 of the CFR including 1910.120, Hazardous Waste Operations and Engineering Response.

4.4 Preferred Alternative

The Preferred Alternative consists of excavation of contaminated soils, demolition of structures, and transport of contaminated materials to the Nevada Test Site. Excavated areas would be restored by filling and regrading. A soil sampling or in-situ surveying program would be utilized to verify the vertical and lateral limits of excavation. Under this alternative, contaminated media would be removed and transported off-site for disposal in a licensed radioactive waste disposal facility. Materials found to be below threshold limits established in the RI/FS would be left on-site.

Different contaminated media would be handled and packaged differently, with the common goal of utilizing on-site radioanalysis to limit the total amount of wastes designated for disposal. Handling procedures for each contaminated unit are described below. Mitigations measures which would be incorporated into the remedial design are discussed in Section 4.6.

Shelter 204. Shelter 204 would be sectioned, scanned with a FIDLER instrument, and containerized for off-site transport. Demolition would be monitored using high-volume air samplers. The air samplers would be used to draw large volumes of air through filters, and the filters would be analyzed daily in the field for alpha activity. Engineering controls designed to minimize resuspension would be utilized.

Apron/Drainage Ditch. The apron would be sectioned and scanned with a FIDLER instrument to separate out material which requires treatment (concrete) or containerization (asphalt) prior to disposal off-site. Demolition activities would have engineering controls designed to minimize resuspension of radioactive contaminants, and all activities would be monitored using high volume air samplers. Approximately 124 yd^3 of asphalt covering contaminated soils in the drainage ditch would require excavation and disposal.

Utility Bunkers. Utility bunkers would be excavated, sectioned, scanned with a FIDLER instrument, and containerized on-site for off-site disposal.

Contaminated Soil. Contaminated soil would be excavated using conventional excavation equipment, containerized on-site, loaded onto trucks, and trucked to a licensed disposal sites. Continuous air monitoring would be performed in work areas as discussed above, and engineering controls for dust suppression such as spraying the soil with water, would be implemented.

Missile Launcher. If located, the missile launcher would be excavated, as described in Section 2.1. The entire launcher, having an estimated volume of 5 yd^3 and an estimated weight of 2 to 3 tons, would also require sectioning and disposal. An estimated 100 yd^3 of contaminated soils associated with the launcher would also require disposal.

Disposal. All contaminated media would be transported off-site to an approved LLW landfill.

All areas excavated would be restored to original grade, covered with topsoil, and replanted with species indigenous to the New Jersey Pinelands.

Potential impacts resulting from the implementation of the Preferred Alternative are discussed in Subsections 4.4.1 through 4.4.7. Mitigations are discussed in Subsection 4.6.

4.4.1 Geology and Soils

Implementation of the Preferred Alternative would not alter geologic baseline conditions (topography, stratigraphy, geological structure, geological resources, unconsolidated rock deposits) within the BOMARC Missile Site. Implementation of this alternative would alter the potential for erosion of contaminated soils during soil excavation. Contaminated soils could be transported off-site via wind and/or water during excavation. In the short term, however, the potential for increased erosion of contaminated soils during excavation activities would be controlled by engineering and safety procedures. Therefore, the potential for soil erosion would remain the same, and the impacts to soils would be negligible. In the long term, contaminated soils would be removed which would reduce the current levels of soil contamination at the site, thus eliminating the potential for erosion of contaminated soil. Remaining soils would be stabilized with vegetation as part of the mitigations, thus preventing erosion problems. In the long term, the potential for exposure of environmental receptors to contaminated soils would be reduced. Long-term environmental consequences resulting from implementation of this alternative are estimated to be negligible.

4.4.2 Hydrology

Consequences resulting from the Preferred Alternative on surface and groundwater are discussed below.

4.4.2.1 Surface Water

Implementation of the Preferred Alternative would slightly alter the surface water baseline conditions within the BOMARC Missile Site. Surface water quality, quantity and flow rate are discussed below.

Surface water quality would not be altered under the Preferred Alternative. Excavation activities may create a short-term increase in soil and sediment erosion due to soil disturbance and exposure as asphalt and/or concrete coverings are removed. The short-term increased potential for radionuclide transport via surface water would be mitigated with engineering and safety controls and therefore negligible (see Section 4.6). In the long-term, contaminants would be removed from the site, thus eliminating the potential for radionuclide transport via surface water. The water itself is not likely to be a source of radioactivity as plutonium and americium are insoluble and adsorb to fine soil. Thus, surface water quality would not be altered by implementation of the Preferred Alternative.

Surface water quantity and flow rate would be altered with implementation of the Preferred Alternative. Existing impervious structures, such as the concrete apron, would be removed. This would result in a long-term decrease in expected run-off of rainfall to drainage channels. There would be long-term channel adjustment resulting from changes in hydrologic and sediment transport regimes. This would primarily affect the upper Elisha Branch. With any increase in erosion or sediment transport activity, there would be concern at this site about mobilization of radionuclides. However, long-term contaminant transport via the surface water pathway at the BOMARC Missile Site is partially mitigated naturally by drainage conditions. The subdued site topography would mitigate the potential for off-site transport of radionuclides over the long-term. Removal of contaminated soils would significantly reduce the risk of off-site transport over the long-term. Long-term impacts associated with the Preferred Alternative would be negligible.

4.4.2.2 Groundwater

Implementation of the Preferred Alternative would slightly alter the groundwater baseline conditions within the BOMARC Missile Site. Groundwater quality, quantity and flow rate are discussed below.

Groundwater quantities and flow rates would be slightly altered under the Preferred Alternative. Existing impervious structures, such as the concrete apron, would be removed. The infiltration of rainwater into the sandy soils in the area is currently low at the site, due to the presence of the mostly impervious surfaces. Removing these impervious surfaces would increase infiltration rates, thereby returning the site to natural conditions. However, because of the low solubility and strong soil adsorption of plutonium and americium, radionuclide availability for transport through the groundwater would be very low. As discussed in Section 3.3.3.3, groundwater sampling and analysis indicated that radioactivity associated with plutonium could not be detected. Groundwater quality would remain the same under implementation of the Preferred Alternative.

Implementation of the Preferred Alternative would not be expected to alter groundwater quality. Groundwater quantity and flow rate would return to more natural conditions. Therefore, both the long-term and short-term impacts to groundwater associated with the Preferred Alternative would be negligible.

4.4.3 Air Quality

Implementation of the Preferred Alternative would result in increased air pollutant loading over a short-term period (i.e., not to exceed one year). This alternative requires substantial site remediation efforts with the potential to generate fugitive dust and gaseous emissions from the operation of heavy equipment and on-site vehicles. In addition, Preferred Aalternative would require a large number of vehicle miles and associated exhaust over a large ROI. Mitigation measures that would be used to minimize the generation of fugitive dust are discussed in Section 4.6.

The impact would be moderate during periods of active site remediation, but negligible along the disposal transport route. It is not expected to result in any violation of AAQS or impact the attainment status of the area. The culmination of the Off-site Treatment Alternative would include grade and ground cover restoration, which would eliminate the need for long-term maintenance and surveillance activities. Long-term impacts would be negligible. Accordingly, implementation of the Preferred Alternative would result in moderate impacts to air quality.

4.4.4 Biology

Implementation of the Preferred Alternative would be expected to alter the vegetative habitat the total number and relative distribution of species at the site in the short term as described below. The potential for plant uptake or animal ingestion and inhalation would be increased in the short term and reduced in the long term. Flora, fauna and the potential biological assimilation of plutonium and americium are discussed separately below.

4.4.4.1 Flora

The Oak-Pine vegetative habitat would be disturbed by implementation of the Preferred Alternative. The old field vegetative zone would be temporarily disturbed. The two state threatened plant species found at the site could potentially be disturbed. Implementation of the alternative would result in the short-term loss of approximately 11,000 ft^2 of Oak-Pine forest habitat surrounding the ponding area and approximately 14,000 ft^2 of old field vegetative habitat. Implementation of the Preferred Alternative would have low short-term impacts on flora communities, as these communities, which are expected to include the threatened plants, would regenerate after activities cease. Over the long-term, after site restoration activities, the site would revert to the Oak-Pine vegetative habitat, potentially displacing threatened plants, thus resulting in moderate long-term impacts.

4.4.4.2 Fauna

In the short-term, soil removal activities would disturb habitat vegetation and may cause localized faunal displacement. The total area affected would be small, and the impacts would be low.

In the long term, if the site fence is not maintained and mowing is discontinued, continued successional changes would eventually result in the old field vegetative zone developing into an Oak-Pine community or an oak-hickory climax community. This would result in faunal habitat displacement and would have a low impact.

4.4.4.3 Organism Contamination Analysis

This section discusses the potential that implementation of the Preferred Alternative has for either increasing or decreasing the possibility of biological assimilation of radionuclides by flora and fauna.

In the short term, activities associated with the search for the missile launcher and soil excavation/disposal would potentially generate fugitive dust. Human and experimental standards have indicated that inhalation of suspended contaminated soils is a critical route of entry (Whicker, 1980). Although there are few faunal receptors at the site, the potential would exist for the inhalation of contaminants during excavation. These potential impacts would be local, temporary, and would be expected to be low.

Implementation of the Preferred Alternative would reduce the bioavailability of plutonium and americium in plant species for animal ingestion and would eliminate the potential off-site transport of contaminants by animals in the long term. Extant levels of contaminated soils would be reduced in the long term. The potential for bioaccumulation or bioassimilation would be further reduced. Implementation of the Preferred Alternative would have negligible long term impacts on flora and fauna with respect to bioavailability contaminants.

4.4.5 Land Use

Implementation of the Preferred Alternative would not be expected to significantly alter land use patterns relative to McGuire AFB, Lakehurst NAEC, Colliers Mills Wildlife Management Area, or Ocean, Burlington, or Monmouth Counties. Land use impacts would be negligible, in part, due to the reasons described in Section 4.3.5. The Preferred Alternative would involve site activities associated with excavation and transportation of contaminated materials. These activities would last approximately one year. The site is currently owned by Fort Dix and is under DoD jurisdiction. In the short-term, implementation of the Preferred Alternative would not conflict with land use plans or jurisdictions proximate to the site, thus having negligible impacts. The use of areas identified as prime farmland, located within five miles of the site, would not be directly altered. In the long-term, excavation and removal of contaminated materials would increase the potential uses of the land. Although long-term land uses in the adjacent jurisdictions are speculative, the site would be remediated and the threat posed by radioactive contamination would be removed. As a result, the potential for conflict with future land use would be eliminated. Therefore long-term impacts to land use would be negligible.

4.4.6 Transportation

Implementation of the Preferred Alternative would temporarily alter traffic volumes on the roads in the vicinity of the BOMARC Missile Site. Contaminated media would be removed from the site for disposal. Potentially, this alternative would generate the most incremental traffic to the area roadway network. The sources of contamination that would be removed include soil, the concrete/asphalt apron, Shelter 204, the utility bunkers, and the missile launcher.

The cleanup activity would require an on-site crew of seven persons for a period of about one year. In addition, other small crews would operate at the site for shorter periods of a few weeks. The small number of commuter trips would be a nominal percentage of the average daily traffic on roadways in the area network.

Internal site traffic would increase as a result of soil being transported to a drop-off point to package the contaminated material. Given an excavation volume of 6,200 yd^3, and assuming a worse-case scenario whereby all soil is contaminated, 1,033 truck trips (assuming a truck capacity of 6 yd^3) would be required to transport the soil to the nearest drop-off point. An estimated one to two round trips per hour would occur. Excavations conducted on the west side of Route 539 would require trucks to cross the road to access the drop-off point. The loaded trucks would turn southbound on Route 539, travel about 400 feet, and turn left into the site. These movements may cause some very temporary slow down along Route 539. The trucks would stay on the paved surfaces, which are sufficient to carry the expected loads.

Potential traffic from heavy trucks would be generated by the Preferred Alternative. All transportation of contaminated materials off-site would be handled by a licensed hauler in compliance with applicable federal, state, and local regulations. All contaminated material would be placed in 9-foot × 9-foot × 16-foot truck-sized containers (48 yd^3 capacity) for off-site transport. The soil volume of 6,200 yd^3 converts to 130 truck size-containers that would be used to move the contaminated soil to the nearest railhead or disposal site.

Additional materials that would require Preferred Alternative are the concrete and asphalt apron in front of Shelter 204, the asphalt-lined drainage ditch, materials from Shelter 204 and the utility bunkers, and the missile launcher, if found. Collectively, these materials (a volume of 1,506 yd^3) would require an estimated 32 trips using truck-size (48 yd^3) containers to remove the material from the site. Including these materials with the previously discussed soil volumes, a worst-case estimate is that 162 trucks would leave the site over the period of one year.

Assuming an even distribution for the truck movements yields a weekly average of two trucks, a volume that would have negligible impacts on the operation of the area road network. To consider short-term peaks, it is assumed as a worst case approach that all work is completed in three months. At this level of activity, approximately three trucks per day would leave the site. This would result in negligible short-term impacts. The relative risks associated with transportation of radioactive wastes has been evaluated in a variety of documents as discussed in Section 4.3.6. In general, previous EIS's which have evaluated the issue related to transportation of radioactive wastes have concluded that transportation of the wastes in compliance with applicable regulations does not pose significant impacts to the environment. In the long-term, transportation impacts would be negligible.

4.4.7 Public and Occupational Health

Implementation of the Preferred Alternative would alter the public and occupational health impacts associated with the site. In the short-term, the potential for occupational impacts would increase slightly. In the long-term, both public and occupational health impacts would decrease. These impacts are discussed below.

4.4.7.1 Public Health Impacts

Implementation of the Preferred Alternative would result in a reduction in the surface soil contamination level for those areas currently above 8 pCi/g. The average surface concentration of ^{239}Pu over the site would be reduced to approximately 4 pCi/g. The public health impacts associated with this level of contamination are discussed below.

4.4.7.1.1 Radiation Dose to Inadvertent Intruders

The resulting average concentration for this alternative would be below the site-specific soil cleanup level, which has previously been shown to result in acceptably low intruder (individual) dose rates (Appendix J, RI/FS). Therefore, the potential individual public health impacts for this alternative were not assessed.

4.4.7.1.2 Potential Radiation Dose to the Surrounding Population

The Preferred Alternative assumes a remediated surface soil contamination of approximately 4 pCi/g. The potential collective dose to the population within 50 miles of the BOMARC Missile Site from atmospheric dispersion of contaminated material was evaluated as described in Section 4.1.7.2 and Section 3.1 of Volume 3, Appendix 3-8. The estimated collective dose rate of 0.4 person-rem per year would be distributed over a population of about 9.2 million persons within 50 miles. The estimated excess fatal cancer rate would be very much less than one per year (1.2×10^{-4} cancers per year) over 9.2 million persons. This cancer incidence rate can be compared to a natural incidence that exceeds 2,500 cancers per year per million persons. This natural incidence rate would correspond to a lifetime incidence of approximately 20,000 cancer deaths per 100,000 individuals (National Research Council, 1990). The 0.4 person-rem per year population dose is well below the 100 person-rem per year upper limit for a negligible impact established in Section 4.2 of Volume 3, Appendix 3-8. The corresponding cancer rate would also be negligible. Therefore, the public health impacts of this alternative are negligible.

4.4.7.2 Occupational Health

Implementation of the Preferred Alternative would slightly alter occupational health impacts. In the short-term, occupational impacts would increase due to activities associated with this Alternative (see Section 4.4). Planned mitigation measures (see Section 4.6) would ensure that occupational impacts are kept to a minimal level. Adequate worker health and safety controls would be further ensured by compliance with applicable portions of OSHA requirements in Title 29 of the CFR.

4.5 On-site Treatment Alternative

On-site Treatment is considered as an alternative to reduce the environmental and health risks posed by radioactive contamination at the BOMARC Missile Site. The On-site Treatment Alternative would involve physical removal of plutonium and americium from contaminated soils, metals, and concrete on-site, concentration of radioactive wastes, and shipment of concentrated wastes off-site for disposal, as detailed in Section 2.5.

The On-site Treatment Alternative would require construction of a 20,000 square-foot process building to house the treatment processes and contain radioactive materials. A decontamination pad for equipment would also be constructed. Contaminated concrete would be sectioned into manageable-sized pieces, a few square feet in area, and its surface decontaminated by a variety of surface-abrasion techniques. Contaminated soils would be excavated and treated using the TRU-Clean® (or similar) process, which would generate an estimated 1,250 yd^3 of concentrated wastes. Following decontamination, sectioned soils would be thoroughly screened on-site for radioactivity. If it is found that the concrete and soils exceed the risk-based cleanup level of 8 pCi/g (determined in the RI/FS, Appendix J), the TRU-Clean® (or similar) process would be repeated. Similarly, if it is found that the concrete exceeds the release limits of NRC Guide 1.86, the decontamination process would be repeated. Decontaminated concrete and soil would be redeposited on-site. Asphalt cannot be treated effectively using the on-site physical treatment methods; contaminated asphalt would therefore be removed and transported for off-site disposal.

The activities associated with each of the contaminated units are summarized below. Mitigation measures would be incorporated into the remedial design are discussed in Section 4.6.

Shelter 204. Contaminated floor and wall materials would be sectioned into manageable-sized pieces and decontaminated on-site in the process building using one or more surface-abrasion techniques. Soil in the launcher pit would be removed and treated using the TRU-Clean® or a similar process. Concentrated radioactive wastes from the decontamination processes would be disposed off-site. Decontaminated materials would be redeposited on-site.

Apron/Drainage Ditch. Concrete overlying the asphalt lining would be sectioned, removed, and treated on-site. The underlying asphalt would be removed and disposed off-site. Contaminated soils below the asphalt lining would be treated on-site using the TRU-Clean® or a similar process. Decontaminated concrete sections and soils would be redeposited on-site.

Utility Bunkers. Utility bunkers would be excavated and removed from the ground after the concrete apron has been removed. Concrete would be sectioned and decontaminated on-site. An estimated two yd^3 of LLW requiring off-site disposal would be generated.

Soils. Contaminated soils would be treated on-site using the TRU-Clean® or a similar process. Contaminated soils would be excavated using engineering controls to minimize release of contaminants. An estimated 4,152 yd^3 of soils would be excavated and decontaminated, which includes a "buffer zone" of currently uncontaminated soils that could become contaminated during removal of contaminated structures. An estimated 1,250 yd^3 of concentrated wastes (contaminated soils) would be generated for off-site disposal. Decontaminated soils would be redeposited on-site, and excavated areas returned to their original grade, covered with topsoil, and planted with native Pinelands species.

Missile Launcher. Attempts would be made to locate the missing missile launcher. Areas around the five geophysical anomalies identified during the RI/FS that might represent the missile launcher would be excavated and visually inspected. All five anomaly areas could require excavation. If the launcher is found, the launcher and surrounding soils would be characterized with respect to radioactivity, and the launcher and contaminated soils would be excavated. Contaminated soils would be decontaminated on-site using the TRU-Clean® or a similar process. The launcher would be either sectioned and decontaminated on-site, or hauled off-site for disposal. The On-site Treatment Alternative is described in more detail in Section 2.2.

The following subsections present a detailed analysis of the environmental impacts associated with the On-site Treatment in each of seven key environmental areas.

4.5.1 Geology and Soils

Implementation of the On-site Treatment Alternative would not alter geologic baseline conditions (topography, stratigraphy, geological structure, geological resources, unconsolidated rock deposits) within the BOMARC Missile Site. Implementation of this alternative would alter the potential for erosion of contaminated soils during remediation activities. The potential for transport of contaminated soils via wind and/or water during soil excavation and treatment activities would be controlled by engineering and safety procedures thus having a negligible short-term impact. Implementation of the On-site Treatment Alternative would reduce extant levels of soil contamination at the site, thus eliminating any potential for contaminated soil erosion in the long term. Remaining soils would be stabilized with vegetation as part of the mitigations, thus preventing erosion problems. Thus, long-term environmental consequences resulting from implementation of this alternative are estimated to be negligible.

4.5.2 Hydrology

Consequences due to implementation of the On-site Treatment Alternative on surface water and groundwater are discussed below.

4.5.2.1 Surface Water

Implementation of the On-site Treatment Alternative would slightly alter the surface water baseline conditions within the BOMARC Missile Site. Surface water quality, quantity and flow rate are discussed below.

Surface water quality would not be altered under the On-site Treatment Alternative. Excavation activities may create a short-term increase in soil and sediment erosion due to soil disturbance and exposure as asphalt and/or concrete coverings are removed. The short-term increased potential for radionuclide transport via surface water would be mitigated (see Section 4.6) and, therefore, negligible. In the long-term, contaminants would be removed from the site, thus eliminating the potential for radionuclides transport via surface water. The water itself is not likely to be a source of radioactivity as plutonium and americium are insoluble and adsorb to fine soil. Thus, surface water quality would not be altered by implementation of the On-site Treatment Alternative.

Surface water quantity and flow rate would be altered with implementation of the On-site Treatment Alternative. Existing impervious structures, such as the concrete apron, would be removed resulting in a long-term decrease in expected run-off of rainfall to drainage channels. There would be long-term channel adjustment resulting from changes in hydrologic and sediment transport regimes. This would primarily affect the upper Elisha Branch. With any increase in erosion or sediment transport activity, there would be concern at this site about mobilization of radionuclides. Design-controlled mitigations would be implemented to reduce potential for erosion, thus resulting in negligible short-term impacts. However, long-term contaminant transport via the surface water pathway at the BOMARC Missile Site is partially mitigated naturally by drainage conditions. The subdued site topography would mitigate the potential for off-site transport of radionuclides over the long-term. Treatment of contaminated soils would significantly reduce the risk of off-site transport over the long-term as on-site contaminant levels would be reduced. Impacts to surface water associated with the On-site Treatment Alternative would be negligible.

4.5.2.2 Groundwater

Implementation of the On-site Treatment Alternative would slightly alter groundwater baseline conditions within the BOMARC Missile Site. Groundwater quality, quantity and flow rate are discussed below.

Groundwater quantities and flow rates would be slightly altered under the On-site Treatment Alternative. Existing impervious structures, such as the concrete apron, would be removed. The infiltration of rainwater into the sandy soils in the area is currently low at the site, due to the presence of the mostly impervious surfaces. Removing these impervious surfaces would increase infiltration rates, thereby returning the site to natural conditions. However, because of the low solubility and strong soil adsorption of plutonium and americium, radionuclide availability for transport through the groundwater would be very low. As discussed in Section 3.3.3.3, groundwater sampling and analysis indicated that radioactivity associated with plutonium could not be detected. Groundwater quality would remain the same under implementation of the On-site Treatment Alternative.

Implementation of the On-site Treatment Alternative would not be expected to alter groundwater quality. Groundwater quantity and flow rate would return to more natural conditions. Impacts to groundwater associated with the On-site Treatment Alternative would be negligible in both the short and long term.

4.5.3 Air Quality

Implementation of the On-site Treatment Alternative would result in increased air pollutant loading over a short-term period (i.e., not to exceed one year). This alternative requires substantial site remediation efforts with potential to generate fugitive dust and gaseous emissions from the operation of industrial equipment and on-site vehicles similar to those described in Section 4.4.3, with the addition of decontamination and physical separation treatment activities, but significantly reduced requirements for off-site disposal. However, decontamination of concrete and steel components would be performed within the confines of a temporary prefabricated structure, and the confinement ventilation system would be equipped with nuclear-grade HEPA filter(s) to mitigate emissions of radioparticulates by 99.9 percent. The TRU-Clean[R] or a similar physical separation process would also be conducted in an enclosed structure with nuclear-grade HEPA filtration. In addition to these actions, various mitigation measures would be used to minimize the generation of fugitive dust during excavation/construction activities (see Sections 4.6).

Locally, the impact would be moderate during periods of active site remediation, but negligible over the disposal transport route. This alternative is not expected to result in any violation of any AAQS or impact the attainment status of the area. This option substantially reduces the need for off-site shipments of waste to burial sites, and is therefore not associated with significant secondary impacts such as impacts due to vehicular exhaust along traffic routes. The culmination of the On-site Treatment Alternative would include grade and ground cover restoration, which would eliminate the need for long-term maintenance and surveillance activities. Long-term impacts would be negligible. Accordingly, implementation of this alternative would result in moderate impacts to air quality.

4.5.4 Biology

Implementation of the On-site Treatment Alternative would be expected to alter both the vegetative habitat and animal species present at the site in the short term. The potential for plant uptake or animal ingestion and inhalation would be reduced in the long term. Flora, fauna and the potential biological assimilation of plutonium and americium are discussed separately below.

4.5.4.1 Flora

Implementation of this alternative would result in the short term disruption and loss of approximately 11,000 ft^2 of Oak-Pine forest habitat and approximately 14,000 ft^2 of old field vegetative habitat. The two state threatened plant species found at the site could potentially be disturbed. The short term impacts would be low. Over the long term, after site restoration activities, the site would revert to the Oak-Pine vegetative habitat, potentially displacing threatened plants. The long term impacts would be moderate.

4.5.4.2 Fauna

In the short term, soil treatment activities would disturb habitats and may cause localized faunal displacement. The total area affected would be small, and the impact would be low.

In the long term, if the site fence is not maintained and mowing is discontinued, continued successional changes would eventually result in the old field vegetative zone developing into an Oak-Pine community or an oak-hickory climax community. This would result in faunal habitat displacement and would have a low impact.

4.5.4.3 Organism Contamination Analysis

This section discusses the potential that implementation of the On-site Treatment Alternative has for either increasing or decreasing the possibility of biological assimilation of radionuclides by flora and fauna.

In the short term, excavation activities associated with the search for the missile launch would potentially generate fugitive dust. Human and experimental standards have indicated that inhalation of suspended contaminated soils is a critical route of entry (Whicker, 1980). Although there are few faunal receptors at the site, the potential would exist for the inhalation of contaminants during excavation. These low impacts would be local and temporary, and would not be transferred through the food chain.

Implementation of this alternative would substantially reduce the extant concentrations of plutonium and americium in the soil. In the long term, implementation of the On-site Treatment Alternative would reduce the bioavailability of plutonium and americium in plant species for animal ingestion and would eliminate the potential for off-site transport of contaminants by animals. Implementation of the On-site Treatment Alternative would have negligible long term impacts on flora and fauna with respect to bioavailability of contaminants.

4.5.5 Land Use

The On-site Treatment Alternative would not substantially alter land use patterns in the vicinity of the BOMARC Missile Site. The site is currently owned by Fort Dix and is under DoD jurisdiction. The On-site Treatment Alternative would involve site activity associated with excavating, treating, and transporting contaminated materials. These activities would be short-term, lasting approximately one year. These activities would not be in conflict with current land uses and land use plans in adjacent jurisdictions. The use of areas identified as prime farmland, located within five miles of the site, would not be directly altered if this alternative were implemented. Therefore, implementation of the On-Site Treatment Alternative would have negligible impacts on current land use.

Removing contamination at the site would increase the potential uses of the land. Although future land uses in the adjacent jurisdictions are speculative, the site would be remediated and the threat posed by radioactive contamination would be removed as a result, the potential for conflict with future land use would be eliminated. Therefore, future impacts to land use would be negligible.

4.5.6 Transportation

Implementation of the On-site Treatment Alternative would temporarily alter traffic volumes in the vicinity of the BOMARC Missile Site. Clean-up activity would be ongoing at the site for about one year. Site-induced vehicle trips would be generated as a result of a daily crew of 11 working on-site, as well as truck trips necessary to remove contaminated material and other waste from the site. The small number of commuter trips would be a nominal percentage of the average daily traffic on roadways in the area network; therefore, negligible impacts would result from these trips.

Internal site traffic would increase as a result of transportation of soil to the decontamination facility. Of the 6,200 yd^3 expected to be excavated and treated, approximately 30 percent (1,860 yd^3) would remain contaminated and would be transported to a drop-off point for off-site disposal. This volume would require 310 truck trips at 6 yd^3 per truck. An estimated one to six round trips per hour would occur. Excavation conducted on the west side of Route 539 would require trucks to cross the road to access the drop-off point. The loaded trucks would turn southbound on Route 539, travel about 400 feet, and turn left into the site. These movements may cause some very temporary slowdown along Route 539, but it is assumed that the trips would not be frequent enough to cause impacts. The trucks would stay on the paved surfaces, which are deemed sufficient to carry the expected loads.

Potential off-site traffic from heavy trucks would be generated by contaminated material required to be disposed off-site. All off-site disposal would be conducted by a licensed hauler, meeting all required Federal, State and local regulations. From the drop-off point, the soil would be containerized for transport to the nearest disposal facility or railroad spur. Contaminated material would be placed in 9-foot × 9-foot × 16-foot truck-sized containers (48 yd^3 capacity) for off-site transport. The 1,860 yd^3 of material that would remain after treatment would require approximately 39 truck movements off-site. Additional materials that may require off-site disposal are the concrete and asphalt apron in front of Shelter 204, the asphalt lining from the drainage ditch, materials from Shelter 204 and utility bunkers, and the missile launcher, if found. These materials, a maximum volume of 1,506 yd^3, would require an estimated 32 off-site truck trips.

Including these materials with the previously discussed soil volumes, a worst-case estimate is that about 71 trucks would leave the site over the period of one year. Mitigations, as discussed in Section 4.6, would be applied. This would not be a sufficient volume increase to cause any noticeable effects in vehicle circulation on the area roadways. The impacts would be short-term and negligible.

Because traffic volume increases would be nominal, no increased maintenance is expected, and accident experience should not change. The relative risks associated with transportation of radioactive wastes has been evaluated in a variety of documents as discussed in Section 4.3.6. In general, previous EIS's which have evaluated the issue related to transportation of radioactive wastes have concluded that transportation of the wastes in compliance with applicable regulations does not pose significant impacts to the environment. In the long-term, transportation impacts would be negligible.

4.5.7 Public and Occupational Health

Implementation of the On-site Treatment Alternative would alter the public and occupational health impacts associated with the site. Although occupational activities associated with this alternative (Section 4.5) would be slightly different than those required for the Off-site Disposal Alternative (Section 4.4), the resulting soil concentration of ^{239}Pu would be the same for the two alternatives. Therefore, the public and occupational health impacts of this alternative would be the same as for the Off-site Disposal Alternative and would also be negligible. Public health impacts are discussed in Section 4.4.7.1, and occupational health impacts are discussed in Section 4.4.7.2. Planned mitigation measures for this alternative are discussed in Section 4.6.

4.6 Mitigation Measures

Mitigations would be incorporated into all but one of the alternatives to reduce potential adverse environmental and human health impacts. Site-specific mitigation plans would be developed for each of the alternatives that would include excavation activities. The mitigation plans would be incorporated into the remedial design specifications developed prior to remedial action. A general outline of the mitigations associated with each alternative are provided below:

Unrestricted Access Alternative. If the Unrestricted Access Alternative were to occur, it would not involve the use of mitigation measures. Current management practices would be discontinued.

NEPA No Action Alternative. The NEPA No Action Alternative would, for the most part, not involve changes from current operational procedures and management practices at the BOMARC Missile Site. However, some additional actions would be taken, including increased sampling, development of a H&SP, and construction of new fencing. The H&SP would follow all requirements of 29 CFR 1910.120 and incorporate the philosophy of maintaining doses as low as reasonably achievable (ALARA), and other applicable requirements.

During excavation and related activities associated with the erection of the new fence, the following mitigation measures would be used to control soil erosion, decrease fugitive dust emissions, and lessen occupational and public health impacts:

- Dirt roads, exposed storage piles, and off-road areas would be watered on an as-needed basis

- Activities would be curtailed during high-wind conditions

- The air samplers would be used to draw volumes of air through filters, and the filters would be analyzed for alpha activity daily in the field. If monitoring indicated resuspension of radionuclides, additional dust suppression techniques would be used. These corrective measures would include spraying the soil with water to minimize resuspension and changing operating procedures on-site to reduce dust resuspension.

- Direct radiation surveys and/or soil sampling analyses would be used to ensure that appropriate controls are implemented to keep occupational doses within regulatory limits and ALARA.

Limited Action Alternative. Implementation of the Limited Action Alternative would incorporate those mitigation measures discussed above. However, due to the need for additional excavation related to the launcher search and possible removal and associated environmental and health risks, the following additional controls would be incorporated into the remedial design for the Limited Action Alternative:

- All active exposed piles would be watered and piles would be covered when not in active use.

- The excavated area would be replaced with clean fill, compacted to original grade, covered with topsoil (as needed), and replanted with locally indigenous flora as soon as feasible.

- Perimeter control measures including construction of silt fences, berms, diversion ditches, sediment traps, and retention basins would be used; activities would be staged to minimize the area of exposed soils during remedial activities and the potential for detachment and off-site transport of contaminated materials.

- Areas of the site which contain the two New Jersey threatened plant species would be protected with fencing or other barriers from site activities and other site disturbances associated with launcher removal activities which could destroy these plant species.

- An outside decontamination pad would be used for decontamination of heavy equipment. Water produced from the decontamination process would be filtered and recycled in order to minimize generation of wastewater requiring disposal. All wastewater from decontamination activities would be collected and containerized for proper off-site disposal.

- Surface water sampling would be conducted during rainfall/runoff events, in order to ensure that contaminated sediments are not leaving the site via the surface water pathway.

- Truck movements would not, to the extent possible, occur during peak commuting hours, and would be reasonably distributed throughout the day.

Prior to beginning excavation, a H&SP would be written to establish standard protective measures and procedures to be taken by on-site personnel. This plan would identify respiratory protective equipment and safety garments (including disposable coveralls and booties) to be utilized by site personnel, identify requirements of a bioassay and dosimetry program, and establish strict site entrance and exit procedures. The site entrance and exit provisions would include:

- A facility to decontaminate personnel who may become contaminated during the course of work

- A facility to decontaminate equipment and transport vehicles before they leave the site

- A convention in which all protective garments would remain on-site after use, and would be disposed of as potential radioactive waste in a licensed facility

- A thorough scanning of all vehicles, equipment, and personnel prior to leaving the site at any time to prevent transport of radioactive materials off-site.

In addition, the H&SP would set strict standards for controls on wastes generated by on-site remedial activities. This plan would be strictly enforced by an on-site Certified Health Physicist who would monitor all remediation activities.

Off-site Disposal Alternative. As with the other alternatives involving excavation, a site specific mitigation plan would be developed for the Preferred Alternative. Mitigation measures that would be incorporated into the implementation of the preferred alternative, include those listed above as well as the following:

- On-site sectioning of concrete would be performed out of necessity outdoors. Strict engineering controls designed to prevent resuspension of contaminated particulates would be implemented. The concrete would be sectioned into manageable-sized pieces, and the layer of asphalt beneath the concrete would be removed. All water and fluids resulting from lubricating or cooling the sectioning equipment would be collected through a vacuum process and vented through a HEPA filter to capture all particulate contaminants.

- Air samplers would be placed to monitor sectioning activities. If dust or airborne contaminants are generated, a separate vacuum blower would also be used to vent the air through a HEPA filter.

On-site Treatment Alternative. Mitigation measures would be incorporated into the remedial design developed as part of the On-site Treatment Alternative, including those described above as well as additional design controls associated with the decontamination process.

- All on-site treatment of contaminated soils, and concrete and steel components would be conducted indoors in a specially constructed process building so that wastes would be effectively contained and protected from wind and water erosion.

- A concrete-lined staging area within the building would serve as the collection point for contaminated soils. This area would have concrete floors sloped to sumps to facilitate collection of leachate. The area would be surrounded by a concrete berm designed to prevent runoff from outside the structure draining into it, and any water from inside the building from escaping.

- A blower system would be installed to maintain negative air pressure inside the structure such that air flow from the inside to the outside would not occur.

- Building exhaust would be processed through a nuclear-grade HEPA filtration system in order to reduce emissions of radioactive particulates by 99.9 percent.

- A similarly contained area would be constructed and designated for storage of concentrated waste residuals awaiting off-site shipment.

4.7 Applicable or Relevant and Appropriate Requirements

NEPA requires that the environmental impact analysis process should be integrated with other applicable environmental review and consultation requirements, just as CERCLA requires that remedial responses adhere to all ARARs. Potential ARARs relevant to the BOMARC Missile Site were identified in the RI/FS (The Earth Technology Corporation, 1992). Section 5.0 of the RI/FS (The Earth Technology Corporation, 1992) contains an inventory and analysis of ARARs, for the BOMARC Missile Site.

Three categories of ARARs are identified by the EPA in CERCLA guidance: chemical-, location-, and action-specific ARARs. Chemical-specific ARARs (e.g., maximum contaminant levels under the Safe Drinking Water Act) are usually health- or risk-based numerical standards. Location-specific ARARs are restrictions placed on activities because they would occur in specific locations (e.g., requirements for management of floodplains and protection of wetlands). Action-specific ARARs are requirements for and limitations on particular treatment or disposal activities for hazardous substances.

4.8 Energy Requirements and Conservation Potential

The energy requirements of each of the alternatives under consideration are discussed below:

- **Unrestricted Access Alternative:** The energy requirements would not change.

- **NEPA No Action Alternative:** The energy requirements would not change.

- **Limited Action Alternative:** There would be a short-term increase in energy requirements associated with excavation and off-site transport of the missile launcher. Energy consumption associated with vehicles on-site used would be minimal. Basic energy conservation practices would be implemented.

- **Off-site Disposal Alternative:** The preferred alternative would be an increase in energy requirements associated with excavation activities. There would be fuel requirements associated with transport of excavated soils to the depository. Energy consumption associated with vehicles used on-site used would be minimal. Basic energy conservation practices would be implemented.

- **On-site Treatment Alternative:** There would be an increase in energy requirements associated with excavation activities. The TRU-Clean[R] process would require electric power which would be accessed from existing power lines. The power requirements would not create an excess demand or major modification to the existing power grid. Energy consumption associated with vehicles on-site used would be minimal. Basic energy conservation practices would be implemented.

4.9 Adverse Environmental Effects That Cannot Be Avoided

The adverse environmental effects that cannot be avoided are discussed for each of the alternatives that are actively under consideration:

- **Unrestricted Access Alternative:**

  - Long-term potential for high impacts as the site may be available for a variety of potential uses which cannot be predicted.

  - Long-term potential for human contact with contaminated media.

- **NEPA No Action Alternative:**

  - Long-term potential for erosion of contaminated materials.

  - Limited increase in vehicular traffic.

  - Potential for alternative uses of the site would be forgone.

- **Limited Action Alternative:**

  - Limited, temporary, localized disruption of surface soil and generation of fugitive dust.

  - Limited localized disruption of flora and fauna.

  - Limited, temporary increase in the potential for off-site migration of contaminants via surface water, air and groundwater pathways.

  - Limited increase in vehicular emissions.

  - Potential for alternative uses of the site would be forgone.

- **Off-site Disposal Alternative:**

  - Temporary disruption of surface soil and generation of fugitive dust.

  - Localized disruption of flora and fauna.

  - Temporary increase in the potential for off-site migration of contaminants via surface water, air and groundwater pathways.

  - Localized increase in groundwater infiltration rates.

  - Increase in vehicular emissions on-site and along transport route.

- **On-site Treatment Alternative:**

  - Temporary disruption of surface soil and generation of fugitive dust.

  - Localized disruption of flora and fauna.

  - Temporary increase in the potential for off-site migration of contaminants via surface water, air and groundwater pathways.

  - Localized increase in groundwater infiltration rates.

  - Increase in vehicular emissions on-site and along transport route.

In all cases (except for the Unrestricted Access Alternative) the effects of all of the alternatives are relatively minor, or can be mitigated (Section 4.6). All of the mitigation measures identified are feasible and would be implemented, as needed.

4.10 Relationship of Short-Term to Long-Term Productivity

The site is not currently used for any productive purposes due to the presence of radionuclides and the corresponding health risk. In the short-term, the Preferred Alternative and two other alternatives, Limited Action Alternative and On-site Treatment Alternative, would cause temporary alterations at the site. However, both the Preferred Alternative and On-site Treatment, would eliminate the long-term potential threats posed by the contamination present at the site. The Preferred Alternative would do so with greater certainty since no sophisticated technology would be required. Based on the risk assessment, three of the alternatives (Unrestricted Access, NEPA No Action, and Limited Action) would not involve remediation of the site to levels that would allow reuse for agricultural or other purposes.

4.11 Irreversible or Irretrievable Commitment of Resources

Irreversible and irretrievable commitments of resources involve commitments of resources required to implement an alternative which could not be recovered at a later time. Implementation of the Limited Action, On-site Treatment, and Off-site Disposal Alternatives would result in the commitment of resources (including energy (fossil fuel and electrical energy) associated with searching for, and possibly excavating, the missing missile launcher. Implementation of the On-site Treatment and Off-site Disposal Alternatives would result in the commitment of resources, including energy (fossil fuel and electrical energy) and other natural resources (construction materials) associated with the construction and demolition of facility buildings. The commitment of these resources is largely irreversible, but the magnitude of the project is not great, and the total consumption of resources is not considered significant. Another resource that would be irretrievably committed is capacity at a radioactive waste disposal facility. However, the total volume of waste that would be generated by any of the alternatives that require off-site disposal would be insignificant in the context of total nationwide radioactive waste production. The On-site Treatment Alternative would minimize this requirement by concentrating radioactive materials. Two of the alternatives (Unrestricted Access Alternative and NEPA No Action Alternative) would not require use of a waste repository. As shown in Table 4-3 there are substantial cost differentials between the five alternatives and within the alternatives that require utilization of a waste repository. However, they would not preclude implementation of remedial alternatives in the future which could restore the site to productive use.

Estimated costs for all of the alternatives except for Unrestricted Access, were calculated as part of the RI/FS. In the FS effort, present worth costs were developed for each alternative, where appropriate. Costs for each alternative were divided into capital costs and operation and maintenance costs. Capital costs include, where appropriate, access controls, excavation of anomalies (to search for the launcher) and/or soil, disposal of contaminants, engineering, etc. Operation and maintenance costs include visual inspections, monitoring/report preparation, etc. The total estimated costs are summarized in Table 4-3. Each of these costs are calculated to present worth, so that the one-time costs can be compared with the long-term costs. Costs are based on a thirty year projection, which is an accepted standard for comparison costing. Costs for NEPA No Action and Limited Action Alternatives would be higher than shown because costs would be incurred in perpertuity as activities involved in these alternatives would be required into the distant future.

Table 4-3
Alternative Cost Summary

Alternative	Potential Disposal Site	Total Estimated Cost[a]
Unrestricted Access	Not Applicable	No Cost
NEPA No Action	Not Applicable	$789,000
Limited Action	Nevada Test Site	$957,000
	Hanford, WA	$1,183,000
Off-site Disposal	Nevada Test Site	$6,800,000
	Hanford, WA	$23,100,000
On-site Treatment	Nevada Test Site	$8,464,000
	Hanford, WA	$13,533,000

[a] Thirty-year present worth cost at 0.10 interest, including capital, operations and maintenance. One-time costs are assumed to be incurred in a period of one year at present worth. Details of the cost estimates are found in the RI/FS Section 5.3.

SECTION 5.0

LIST OF PREPARERS

5.0 LIST OF PREPARERS

COORDINATION

Tom Hastings, Managing Senior, TETC
Purdue University, M.S. Environmental Management, 1977
Purdue University, B.A. Liberal Arts, 1975

Quentin Gillard, Managing Senior/Senior Environmental Scientist, TETC
University of Chicago, Ph.D. Geography, 1975
University of Chicago, M.S. Geography, 1971
University of Nottingham, B.A. Geography, 1969

Donna Bishop Collins, Principle Investigator, SAIC
Colorado State University, B.S. Geology, 1974

Robert K. Kennedy, Division Manager, SAIC
University of Oklahoma, Ph.D. Plant Ecology/Geography, 1973
Iowa State University, M.S. Ecology Soils, 1969
South Dakota State University, B.S. Botany/Biology, 1967

SOILS AND GEOLOGY

Mel Tyree, Senior Staff Geologist, TETC
Marshall University, B.A. Biology, 1985
Marshall University, B.A. Geology, 1980

HYDROLOGY

Derrick Coleman, Senior Hydrologist, TETC
The Johns Hopkins University, Ph.D. Geomorphology, 1982
University of California, Berkeley, B.A. Geography, 1975

John Tewhey, President, John D. Tewhey Associates, Inc.
Brown University, Ph.D. Geochemistry, 1975
University of South Carolina, M.S. Geology, 1968
Colby College, B.A. Chemistry and Geology, 1965

AIR QUALITY/METEOROLOGY

Debra Ryan, Senior Meteorologist, SAIC
Pennsylvania State University, B.S. Meteorology, 1977

Bruce K. Wooten, Staff Engineer, SAIC
San Diego State University, MBA Candidate, 1991
Case Western Reserve University, B.S. Systems Engineering, 1985
U.S. Naval Academy, Systems Engineering, 1983

Howard Pippen, Health Physicist, SAIC
San Diego State University, M.S. Candidate, Radiological Health Physics
Florida State University, B.S. Biological Sciences, 1970

BIOLOGY

Mel Tyree, Senior Staff Geologist, TETC
Marshall University, B.A. Biology, 1985
Marshall University, B.A. Geology, 1980

LAND USE

Carl E. Mitchell, AICP, SAIC
Michigan State University, M.U.P. Urban Planning, 1976
Old Dominion University, B.S. Biology, 1974

Isaac Diwan, Environmental Scientist, SAIC
Hebrew University of Jerusalem, M.S. Environmental Biology, 1987
Trent University, B.S. Biology/Environmental Resource Studies, 1983

TRANSPORTATION

Carl E. Mitchell, AICP, SAIC
Michigan State University, M.U.P. Urban Planning, 1976
Old Dominion University, B.S. Biology, 1974

Anthony C. Heitzman, Jr., Civil Engineer, SAIC
University of Tennessee, M.S. Candidate, Civil Engineering
University of Tennessee, B.S., Civil Engineering, 1987

DEMOGRAPHICS

Carl E. Mitchell, AICP, SAIC
Michigan State University, M.U.P. Urban Planning, 1976
Old Dominion University, B.S. Biology, 1974

PUBLIC HEALTH

Mark D. Otis, Division Manager, Environmental Analysis and Performance Assessment, SAIC
Colorado State University, Ph.D. Radioecology, 1983
Colorado State University, M.S. Radiation Health, 1973
University of Colorado, B.S. Physics, 1972

Michael McKenzie-Carter, Staff Scientist, Environmental Analysis and Performance Assessment, SAIC
Oregon State University, M.S. Radiation Health, 1985
Humboldt State University, B.A. Zoology, 1981

Marilyn J. Case, Environmental Scientist, SAIC
University of Florida, M.S. Environmental Engineering and Health Physics, 1981
University of Florida, M.S. Systems Ecology, 1976
Susquehanna University, B.A. Biology, 1973

James Roberts, Staff Scientist/Certified Health Physicist, SAIC
Colorado State University, M.S. Radiation and Radiation Biology, 1981
Colorado State University, B.S. Physics, 1978

TECHNICAL EDITING

Mark Withers, Technical Editor, TETC
University of California, Los Angeles, M.A. Candidate, Geography, 1991
University of California, Los Angeles, B.A. General Chemistry and Geography - Ecosystems, 1981

Jennifer Smith, Staff Geologist, TETC
Washington University, M.A. Earth and Planetary Sciences, 1989
Franklin and Marshall College, B.A. Geology, 1987

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SECTION 6.0

LIST OF AGENCIES AND PERSONS CONSULTED

6.0 LIST OF AGENCIES AND PERSONS CONSULTED

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U.S. Environmental Protection Agency	
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Resource Conservation and Recovery Act Programs	J. Brogard
New Jersey Facilities Program, Corrective Action	K. Lumino
Federal Facilites	B. Wing
Environmental Protection Agency Project Manager, BOMARC Missile Site	B. Conetta
Air Programs	G. Musumeci
	R. Werner
Environmental Impacts Branch	V. Snitzler
Office of Radiation	J. Russell
	C. Nelson
U.S. Fish and Wildlife Service	C. Day

STATE OF NEW JERSEY

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Department of Environmental Protection	S. Boykewich
	J. Reese
	R. Porustski
Development and Redevelopment Authority	
Area Planning	J. Shue
Department of Transportation	
Division of Roads and Highways	C. Miller
Travel Protection Unit	C. Aufscheider
Traffic Counts	J. Panzitta
	M. Newman
National Guard	
Hazardous Waste Specialist	Sgt. Shenko
Historic Preservation Officer	N. Zerbe

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Traffic Engineer	J. Pavlak
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Ocean County	
Planning Board	A. Avery
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Department of Transportation	
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Environmental Health Scientist
Special Programs Group
Center for Environmental Health and Injury Control
Centers for Disease Control
Atlanta, GA 30333

Federal Aviation Administration
JFK International Airport
Federal Building
Jamaica, NY 11430

Environmental Protection Agency
Region II
Attn: Mr. Paul Ingrisano
Remedial Project Manager
26 Federal Plaza
New York, NY 10278

Mr. Michael T. Chezik
U.S. Department of Interior
Fish and Wildlife Service
P.O. Box 534
705 White Horse Pike
Absecon, NJ 08201

Mr. Marvin Krotenberg
Regional Environmental Officer
U.S. Department of HUD - Region II
26 Federal Plaza, Room 3542
New York, NY 10278

Mr. Elmer DeRitter
Veterans Administration
Loan Guarantee Officer
20 Washington Place
Newark, NJ 07102

Mr. Ramzi A. Himaia
State Environmental Coordinator
Farmers Home Administration
1 Vahlsing Center
Robbinsville, NJ 08691

State Director, Eastern States
U.S. Department of Interior
Bureau of Land Management
350 S. Picket Street
Alexandria, VA 22304

Mr. Joseph T. Fromme, Director
Department of Interior
Office of Environmental Project Review
Room 4260, Interior Building
18th and C Streets, NW
Washington, DC 20240-0001

National Environmental Coordinator
Department of Agriculture
Environmental Activities Branch
Ecological Services Division
Room 6155, South Agriculture Building
14th Street and Independence Avenue, SW
Washington, DC 20250

Chief, Planning and Evaluation Branch
Department of Agriculture
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Agriculture Stabilization and Conservation Service
Room 4714, South Agriculture Building
Washington, DC 20250

Mr. Jeff Steel
U.S. Department of Energy NE-60
James K. Polk Building
National Center Building #2
2521 Jefferson-Davis Highway
Arlington, VA 22202

Mr. Steven R. Woodbury
Environmental Compliance Division
Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585

<u>State Agencies</u>

New Jersey Div of Fish, Game and Wildlife
Soil Conservation Service
Attn: State Conservationist
1370 Hamilton Street
Somerset, NJ 08873

Ms. Gwen Barunas
New Jersey Department of Environmental Protection and Energy
Division of Hazardous Waste Management
Bureau of Case Management
CN028
401 E. State Street - 5th Floor West
Trenton, NJ 08625

Mr. Stephen Boykewich
New Jersey Department of Environmental Protection and Energy
Bureau of Environmental Radiation
CN411
380 Scotch Road
Trenton, NJ 08625

Mr. Lawrence Schmidt
Director, Planning Group
New Jersey Department of Environmental Protection and Energy
Office of the Commissioner
CN402
South Broad and Front Streets
Trenton, NJ 08625

Mr. Nelson Silver
Department of Community Affairs
Division of Local Government Services
Local Management Services
CN803
South Broad and Front Streets
Trenton, NJ 08625-0803

Mr. Terrence D. Moore
Executive Director
New Jersey Pinelands Commission
15 Springfield Road
New Lisbon, NJ 08064

Mr. Andy Mikula
New Jersey Department of Environmental Protection and Energy
Division of Environmental Quality
CN027
Trenton, NJ 08625

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Jackson, NJ 08527

Mr. Dane Wells, Chairman
Jackson Township Environmental Commission
RD 4, Rte 528, Box 1000
Jackson, NJ 08527

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Other

Mr. Ron Mis
GWM Remedial Services
100 Nassau Park Blvd.
Princeton, NJ 08540

Mr. Edwin M. Ryan
2 Magnolia Avenue
New Egypt, NJ 08533

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SECTION 8.0

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